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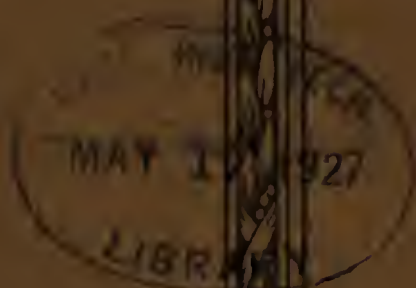
AUGUST 1925

BULLETIN E-104

Motion Picture and Stereopticon
Projection with Mazda Lamps



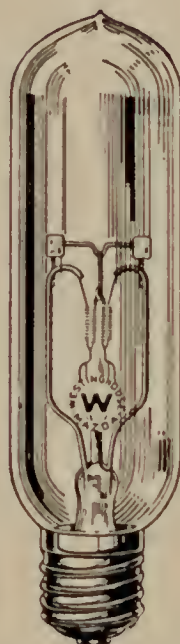
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Motion Picture and Stereopticon Projection with Mazda Lamps



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MOTION PICTURE PROJECTION

Introductory

EVERYONE is familiar with the phenomenal growth of the motion picture industry from its meagre beginning twenty years ago to its present rank among the leading activities of the country. A prominent factor in the success of the motion picture is the continued improvement which has been made in projection. In this branch of the industry the Mazda lamp has come to play an important part.

Where the conditions of picture size and projection distance make it practicable to employ Mazda lamp projection, the following primary advantages are realized:

Advantages of Projection With Mazda Lamps

Cleanliness: Mazda lamp projection is clean, and no poisonous gases are liberated; the air in the projection booth is free from soot and carbon particles, insuring healthful working conditions for the operator.

Economy: Projection with the Mazda lamp represents a distinct economy for two reasons: The power consumption is only a fraction of that with the arc; and less ventilation is required.

Steadiness: The Mazda lamp produces a perfectly steady intense source of light. This is a great advantage over the flickering which frequently accompanies arc projection.

Quietness: Projection with the Mazda lamp is absolutely quiet. There is no noise from the singing or hissing of the arc or from the motor generator.

Softness of Light: The Mazda motion picture lamp produces an agreeable softness in the projected picture, and maintains a uniform color quality entirely satisfactory for colored pictures.

Comfort: Due to the lower power consumption the Mazda lamp outfit radiates much less heat in the projection room, adding materially to the comfort of the operator.

Simplicity: The Mazda motion picture lamp and outfit are much more simple to operate than the arc. The initial adjustment of a new lamp in the housing must be carefully made but no further adjustments of lamp or housing are needed throughout the entire life of the lamp. This enables the operator to devote more time and attention to the actual projection of the picture.

Operating Limits

Satisfactory motion picture projection with present style Westinghouse Mazda lamps is feasible in most cases with picture sizes up to 12 feet by 16 feet and projection distances up to 100 feet. Local conditions may somewhat increase or decrease this limit. Where the picture requirements are approximately those mentioned above or less, it is logical to install machines equipped for Mazda lamp operation and benefit by the many advantages which this form of projection makes possible.

STANDARD SIZE INSTALLATIONS

THE LAMP

Sizes: The Westinghouse Mazda lamp for motion picture projection is made in two sizes: 900 watts, 30 amperes, 30 volts; and 600 watts, 20 amperes, 30 volts. The 900-watt lamp is used in theatres and in the larger auditoriums in high schools, public buildings, and similar places requiring a fairly large picture and a distance of 75 feet or more from projector to the screen. The 600 watt lamp is more suited for operation on country home lighting plants, or wherever the current supply is limited.

Best Filament Form: Technical men who are unfamiliar with lamp design frequently assume that the best form to give to the filament of the motion picture lamp would be a thin plate. There are very weighty reasons against using such a form; to make this clear would require a discussion of the involved relations of voltage, current, brilliancy and life. It is unnecessary to go into that aspect of the matter because the average brilliancy of the present filament is comparable to that of a smooth plate at the same temperature, and the sole respect in which a plate has any advantage is in perfect evenness of brightness. This is of minor consequence when the proper optical train is used. In all other respects the plate would be greatly handicapped.

Reason for 30 Volt Rating: A question which arises in the minds of many operators is why this lamp is not constructed to operate on 110 volts, and thus eliminate the accessory apparatus such as rheostats, step-down transformers and automatic regulators. In order to utilize the maximum amount of light the filament must be concentrated in a very small space. The filament for a 110-volt lamp is necessarily very long, and if wound into the small space required for an efficient motion picture lamp the coils would be so close together that the lamp would arc across and burn out. The best

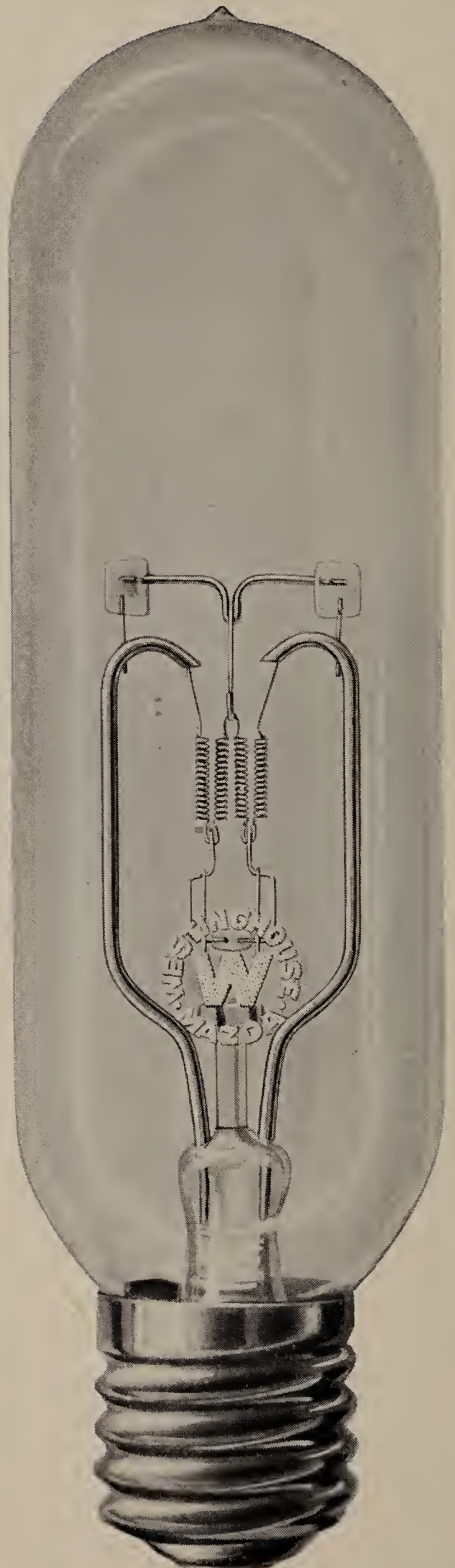


Fig. 101

solution is to increase the amperage and reduce the voltage, thereby making it possible to use coils of short thick wire. This adds to the strength of the filament and reduces the heat losses.

The dimensions of the light source in the present type of motion picture lamp have been determined through long research, to produce the greatest possible amount of light in the most efficient way.

Purpose of Mirror: This filament of thick wire is of helical wound coils with very small pitch, and the inevitable separations between the coils are filled in by the proper arrangement of a concave spherical mirror mounted behind the lamp. Thus the light source may be viewed in any direction within the angle covered by the condensing lens and it will show an almost unbroken combination of mirror images and filament. The mirror serves an additional purpose in restoring to the filament a large amount of radiated energy which would otherwise be wasted. Consequently the power required is somewhat reduced. To sum up, the mirror brings about evenness of source, higher mean brilliancy and lower wattage.

Guides for Filament: By a radical departure from the old type of construction, it has been possible to overcome two of the weakest points, that of filament breakage in handling, and distortion due to the warping of the filament and consequent reduction of lamp life. Ever since the introduction of the 900-watt lamp, as far back as 1918, the short life has been a problem to the engineers. This type of lamp has an average rated life of 100 hours of continuous burning, and during this period the filament is required to remain parallel without distortion which, due to the high temperature at which the lamp operates, is impossible to accomplish without providing for expansion of the filament.

When these coils of wire become white hot they expand, and with the old method of rigid supports, they could not go up or down, so all that was left was to warp sideways, with the result that the mirror reflection could not fill up the spaces between the coils, and consequently there resulted uneven illumination, which showed itself in the colored streaks upon the screen, commonly called "rainbows." Overcoming the distortion of the filament was accomplished by practically hanging the filament upside down and changing the two bottom supports to a sliding guide as shown in Figure 101. The filament expands and contracts just as conditions require, yet the supports control it and keep it in perfect alignment during these movements, allowing the mirror to fill up the intervening spaces properly and consequently producing an even screen picture. Not only does this construction prolong the active life of the lamp, but it has practically eliminated breakage in transportation, which was due to the difficulties encountered in producing good spot welds caused by the characteristics of the various metals, nickel, tungsten and molybdenum, that entered into the construction of the supports.

Glass Bulb: The bulb, because of the extreme heat produced when this lamp is burning, is made of a special glass. The size is known as T-20, which in the terms of lamp manufacture means a tubular bulb 20/8 inches or $2\frac{1}{2}$ inches in diameter. The tubular bulb is used to allow the closer placing of the filament with respect to the condenser and mirror, and so that the blackening on the inside of the bulb will be well above the filament.

Gas-Filled Lamp: The lamp is of the Mazda C or gas-filled type. The gas, about 80% argon and 20% nitrogen, makes it possible to operate the

filament at a much higher temperature thereby adding greatly to the efficiency and brilliancy of the lamp. The use of a very heavy filament also adds to the temperature at which it is possible to operate.

Filament Temperature: How closely to the melting point of tungsten the filament is operated, may be seen from Figure 102.

	FILAMENT TEMPERATURE	
	Absolute	Fahrenheit
40 WATT MAZDA B LAMP	2500°	4040°
200 " " C "	2875°	4715°
900 " MOTION PICTURE LAMP	3300°	5480°
MELTING POINT OF TUNGSTEN	3675°	6155°

Fig. 102—Lamp Filament Temperature Chart

Life: The brighter the motion picture lamp is operated the shorter will be its life. The life basis on which the moving picture lamps are designed is one hundred hours. Note that this is an average figure. Individual lamps will have different lengths of life but the average will be approximately the figure stated. This makes the lamp renewal cost comparable with the present arc carbon renewal cost. Cost per lumen on the screen for combined lamp renewals and power is not a final guide, because satisfactory screen illumination from the patron's standpoint is of greater importance than the cost differences involved. Hence the preference is for a comparatively short lived lamp of high brilliancy.

However, any increase over the normal current of a motion picture lamp will greatly reduce the life. For this reason it is absolutely essential that the current be held at exactly 30 amperes or at 20 amperes depending on the lamp rating.

Base and Leads: The base of this lamp is of the large size known as a Mogul base, 1½ inches diameter, providing ample contact surface to carry the necessary current. A big improvement has been the substitution of welding for the solder at the points where the lower wires are connected to the base.

The heavy nickel lead wires shown in Figure 101 serve a double purpose of carrying the current to the filament and forming the rigid frame to support the other parts.

Detailed Specifications: The following table gives the detailed specifications on the standard 900 and 600-watt lamps:

TABLE I
MAZDA LAMPS FOR MOTION PICTURE PROJECTION

Volts	Amps.	Watts	Hours Life Average	Bulb	Diam. of Bulb	Screw Base	Max. Overall Length	Light—Center Position*	Position of Burning	Std. Pkg. Quantity	List Price
28-32	20	600	100	T-20	2½"	Mogul	9½'	'4¾"	Tip-up	6	\$6.00
28-32	30	900	100	T-20	2½"	Mogul	9½'	'4¾"	Tip-up	6	6.75

*Distance from base contact of lamp to center of filament.

OPTICAL SYSTEMS

FUNDAMENTAL PRINCIPLES

Essential Parts: Figure 105 shows the necessary elements of an optical system for motion picture projection. L is a standard Mazda motion picture lamp of the type described previously. It is turned so that the plane of the filament is perpendicular to the optical axis; *i.e.*, the line M-O which passes through the center of the mirror M, the center of the lamp, the condenser C, aperture A, and objective lens D.

Condenser: Referring to Figure 105 it will be seen that the condenser C collects light from the lamp and redirects it to the aperture at A, where the film is located. In addition to the necessity of having the largest amount of light strike the film, it is essential that this light should come in the proper direction to pass on through the objective lens and to the screen.

Figure 103 shows what would happen if the film were illuminated merely by direct light from the lamp without use of a condenser. In this case, even if as large an amount of light should strike the film as in Figure 104, only a small portion of this would pass through in the proper direction to strike the objective lens and be used. Any light which does not enter the objective lens cannot be used in projecting the picture on the screen. The location of the lamp almost against the film, as shown in Figure 103, would also be impracticable because of fire hazard.

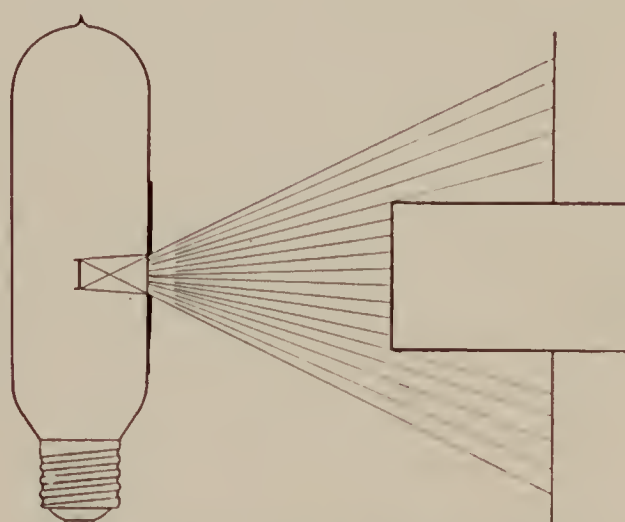


Fig. 103—Showing Lost Light When Condenser Not Used

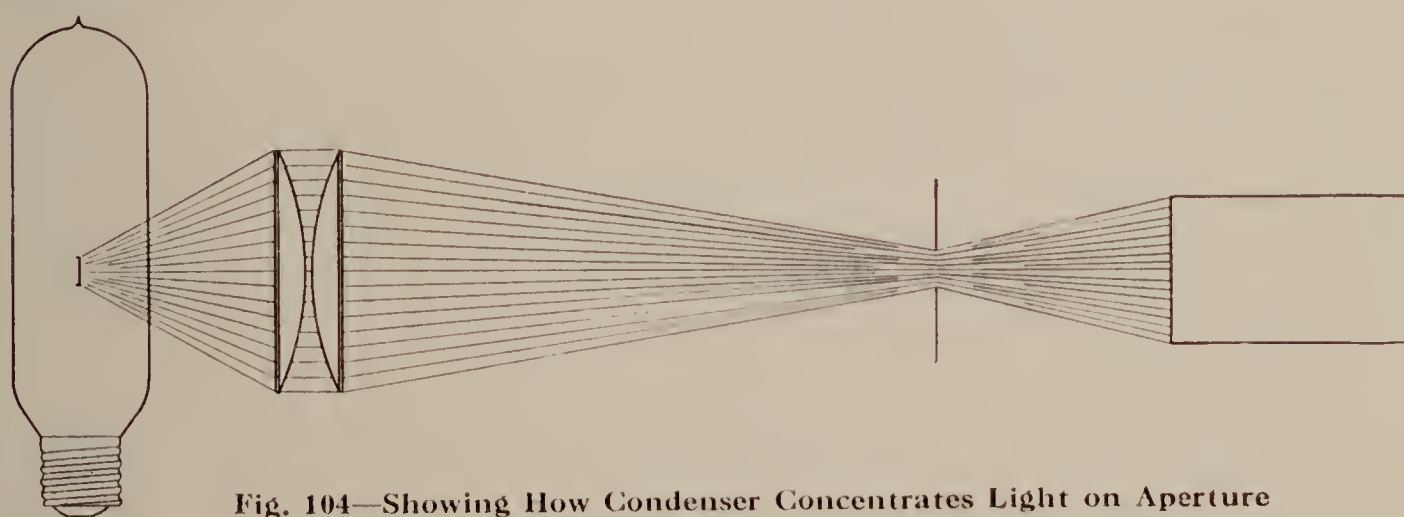


Fig. 104—Showing How Condenser Concentrates Light on Aperture

Aperture: The aperture A is a rectangular hole in a metal plate, through which the light passes. This aperture is made exactly the size necessary to include one complete picture on the film. As the film passes down along the rear face of the aperture plate, the latter thus forms a frame for the picture.

Spherical Mirror: The spherical mirror M increases the amount of illumination on the screen by utilizing a large part of the light which is thrown out from the rear of the lamp, and which, when it strikes the

spherical mirror, is reflected back in such a manner that a bright image of the lamp filament is formed at the place where the filament itself is located. This image, when correctly placed, fills in the gaps between the original four sections of the motion picture lamp filament, producing almost a solid wall of light.

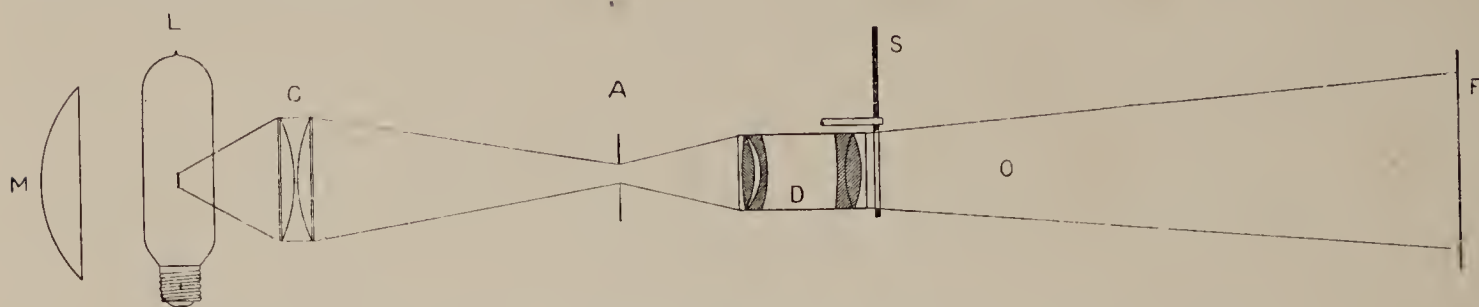


Fig. 105—Complete Optical System for Projection with Mazda Lamp

Projecting the Picture on the Screen: The light, after passing through the aperture and the film, strikes the objective or projection lens D. This lens forms a greatly enlarged image of the film on the motion picture screen. An idea of how this image is formed will be obtained by referring to the following sketches.

Projection Through Pin Hole: Figure 106 shows the elementary method of forming an image of an object, shown here as an arrow. Light from the point of the arrow passing through the pin hole in the plate is directed to a certain point on the screen on the other side of the plate. In a similar manner, any light starting from the tail of the arrow and passing through the pin hole will be thrown at one point on the screen, or in the same way, light from any other point of the same arrow will be thrown on one particular point on the screen. The result naturally is an image of the original object, varying in size as the screen is moved.

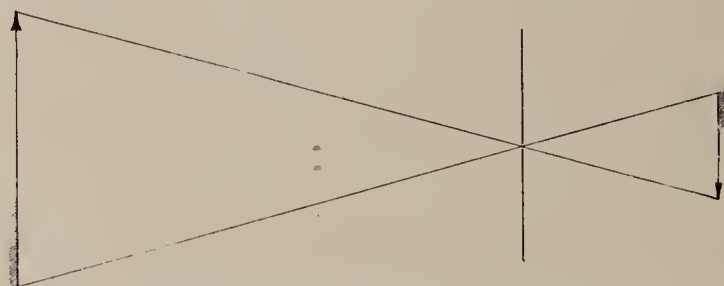


Fig. 106—Projection of Image Through Pin Hole

Projection Through Lens: The great objection to this very simple method of forming an image is the fact that so small an amount of light can be made to pass through the pin hole. If the pin hole is enlarged in an attempt to overcome this defect a blurred image will result. Some method must be found of considerably enlarging the hole so that a large amount of light may pass through and at the same time of controlling the light in such a way that a clear image will result.

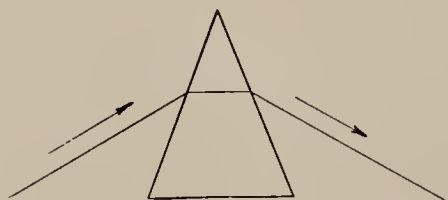


Fig. 107—Showing How Ray of Light is Bent by Prism

It has long been known that light on passing from air into glass, or from glass into air, is bent according to definite laws. For instance, a ray of light striking a prism as shown in Figure 107 will be bent on entering the glass and again on leaving the glass so that it takes the path shown. This principle has been very skillfully used in designing lenses for image formation.

Simple Projection Lens: In Figure 108 is shown one of the most simple types of lens which can be used for this purpose. All the light which starts from the point of the arrow and passes through the lens is bent in

such a way that it comes back to a certain point or focus on the screen, on the other side of the lens.

In the same way light from any other point of the arrow is brought to a focus at some particular point on the screen and the result is an inverted image of the original object. This image will be brighter than in the pin hole method in proportion to the much greater area of the lens as compared to the area of the pin hole.

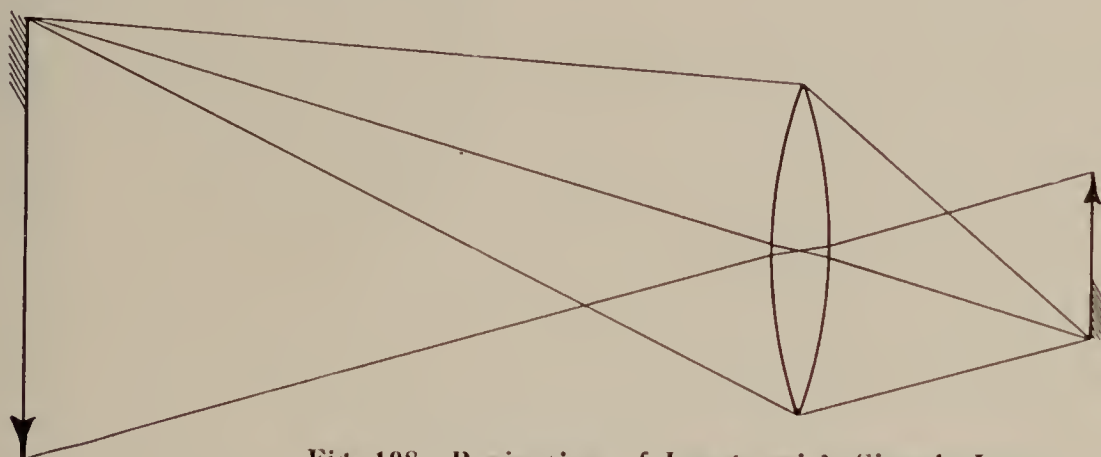


Fig. 108—Projection of Image with Simple Lens

Commercial Type Projection Lens: Unfortunately, the image which can be obtained with a simple lens of the type shown above is not absolutely sharp at all points and is sometimes subject to narrow fringes of color. These undesirable effects are known as “spherical aberration” and “chromatic aberration,” and it is to overcome these defects that the more complex type of lens shown in Figure 109 has been designed. This represents the actual construction of the typical objective lens, which are in commercial use today. Certain of the individual lenses in

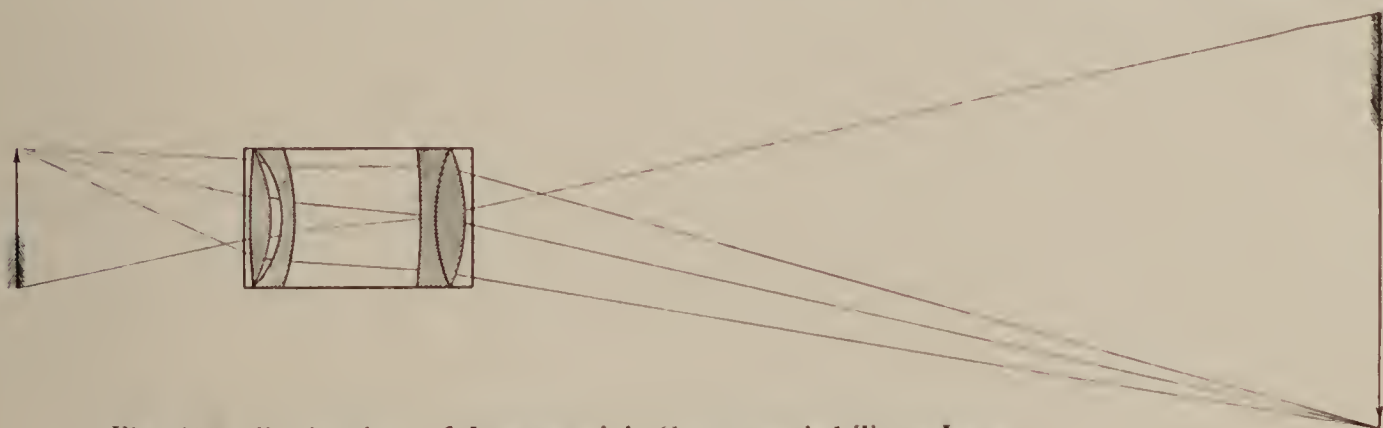


Fig. 109—Projection of Image with Commercial Type Lens

this objective are made of different kinds of glass (commonly known as crown and flint) which have different properties for bending or refracting the light rays. The surfaces of the different individual lenses are skillfully designed and accurately ground in such a way that the faults of the simple type of lens shown in Figure 108 are overcome and a clear sharp image of the picture is thrown on the screen.

Rotary Shutter: In Figure 105, page 6, S is a rotary shutter which cuts off the light while the film is moving, yet allows the picture to be thrown on the screen while the film is momentarily held stationary. The motion picture is, of course, merely a succession of rapidly changing still pictures, each succeeding the other while the visual impression of the preceding one still lingers.

Screen: F, Figure 105, page 6, is the screen to receive the picture which is projected by the optical system. The light that it reflects back to the eye is the only portion which enables the formation of a visual picture.

PLANO-CONVEX CONDENSER SYSTEM

There are several different types of condensers in use at the present time. This is such a vital part of the projection system that the more important of these will be described in detail starting with the plano-convex, shown as a part of Figure 105, page 6.

Figure 110 shows plano-convex lenses of the type used for motion picture work. One side of each of these lenses is perfectly plane or flat while the other is ground to the same shape as a portion of the surface of a ball or sphere.

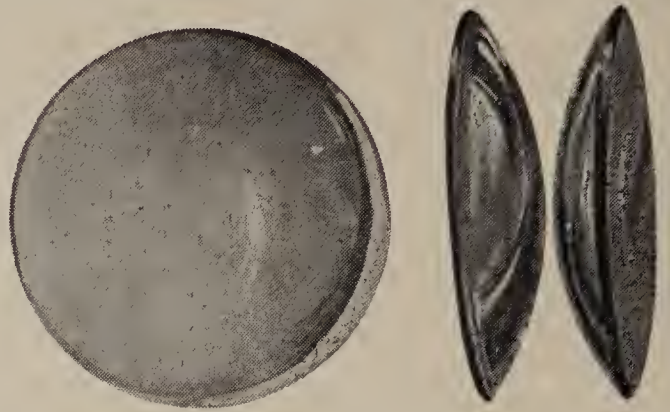


Fig. 110—Plano-Convex Lenses

Focal Length: Plano-convex lenses are rated according to their focal lengths. If parallel rays of light strike the surface of a plano-convex lens in the manner shown by Figure 111, they will be brought to practically the same point on the extended axis of the lens. The distance F from this point to the flat surface of the lens is a practical measure of the focal length. Lenses of different degrees of curvature will naturally have different focal lengths. The most common plano-convex lenses used in motion picture work are approximately $4\frac{1}{2}$ inches in diameter and have focal lengths of $6\frac{1}{2}$ inches and $7\frac{1}{2}$ inches.

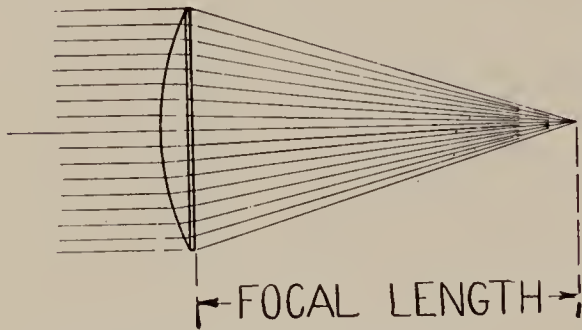


Fig. 111—How to Determine Focal Length of a Lens

Figure 104, page 5, shows the most common type of plano-convex lens combination which consists of a $6\frac{1}{2}$ -inch focus lens in the rear and a $7\frac{1}{2}$ -inch in the front, or toward the film.

Reason for Two Condenser Lenses: The question may easily be asked, why are two lenses used instead of one? In order for one lens of this type to bend the light a sufficient amount to bring it to the aperture, the lens would have to be very thick at its center portion. In a thick lens of this sort the glass annealing is troublesome, and the errors due to spherical aberration and chromatic aberration are very large.

Spherical Aberration: In all very thick lenses, as shown in Figure 112, rays of light are not all brought to exactly the same focal point. The rays of light which strike the lens near the outer edge are bent a greater amount than those which pass through the lens near the center and the result is that the rays cross each other at different distances along the axis, forming instead of one clear image of the object a succession of more or less indistinct images. This is spherical aberration. Since it is desired to form an image of the lamp filament a short distance away from the aperture and no image at the aperture, too much spherical aberration is undesirable. A slight amount is theoretically of more benefit than harm since it tends to narrow down the beam of light and thus allow more of the beam to pass through

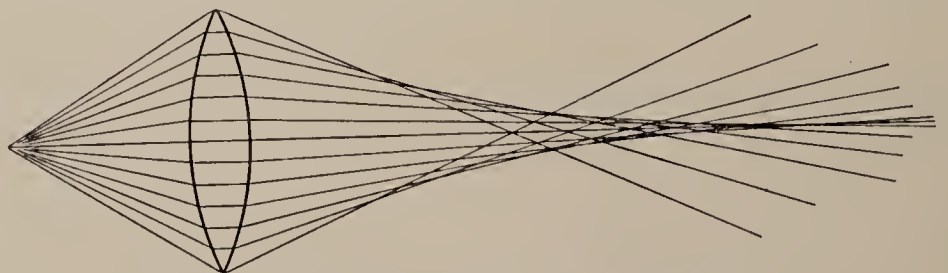


Fig. 112—Effect of Spherical Aberration

the aperture; an advantage, however, more theoretical than practical.

Chromatic Aberration: Chromatic aberration can best be explained by considering what the effect would be if the lens had only this quality, and no spherical aberration. In this case a white object placed at O, Figure 113, on one side of the lens would have images formed along the optical axis at different distances from the lens, according to the spectrum. That is to say, there would be a red image formed at A and a violet image formed at B, and images of all the other colors of the spectrum would be formed at certain points in between, because light of longer wave-lengths (reds, yellows, etc.) is bent less than short wave-lengths. As a matter of fact, most commercial condenser lenses are subject to both

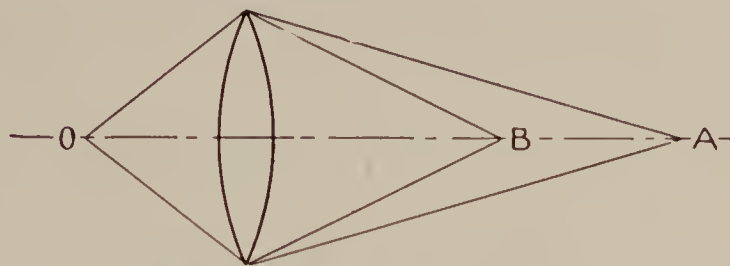


Fig. 113—Effect of Chromatic Aberration

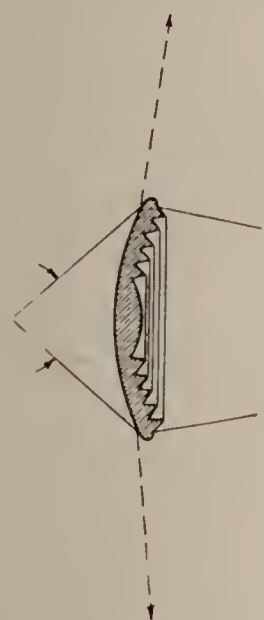


Fig. 115—Corrugated Lens Showing Light Lost by Reflection

spherical and chromatic aberration so that there is practically an infinite number of images due to both causes, extending a certain distance along the axis of the beam. When the lenses are carefully shaped and polished the color images overlap and neutralize one another so that colors are usually encountered to an objectionable extent only near the edges of the beam. Since the beam is always a little larger than the aperture, this color fringe strikes the aperture plate and never reaches the objective lens.

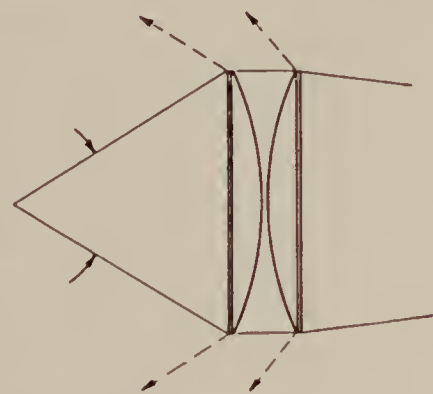


Fig. 114—Plano-Convex Lenses Showing Light Lost by Reflection

Corrugated or Prismatic Condenser: In addition to the double lens plano-convex condenser, another quite common system is that of the single corrugated lens, pressed with concentric prism-rings on its concave side, after the Fresnel principle. Figure 115 illustrates the type.

Comparative Merits of Two Types of Condensers: Each motion picture condenser lens system has certain inherent advantages and disadvantages.

The plano-convex lens combination is always so placed that the flat side of one of the lenses is toward the lamp filament. It will be seen from Figure 114 that the light from the lamp strikes the flat surface of the plano-convex lens, especially near the edges, on much less of a slant than is the case with the corrugated lens. Although the corrugated lens intercepts light from the lamp at a somewhat larger solid angle, a considerable amount of this light is reflected from the rear surface of the condenser and lost on account of striking the glass at such an oblique angle. In considering these two lenses from this standpoint, the gain in light intercepted by the corrugated lens due to this larger working angle is just about offset by the reflection loss described.

With a plano-convex lens the working distance between the lens and aperture is somewhat longer than in the case of the corrugated lens. This means that a much narrower cone of light strikes the aperture, and the cone which is formed by the light after it passes through the aperture

and is traveling towards the objective lens is also narrower. For this reason, the objective lens is able to utilize a much larger proportion of the

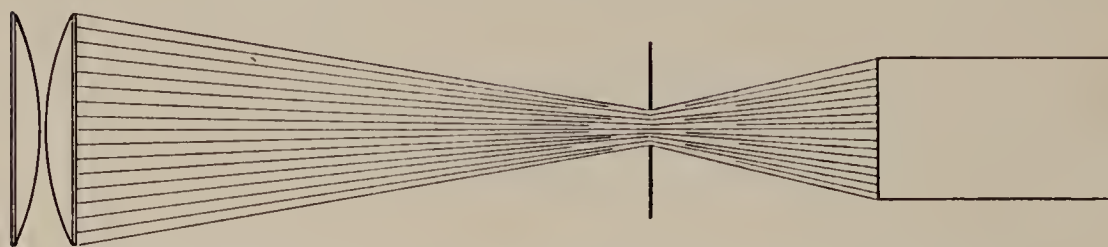


Fig. 116—Plano Convex Condensers Showing Long, Narrow Cone of Light

light than if the cone were so wide that considerable light would pass outside of the objective. This fact is particu-

larly marked with the quarter size objectives or with any objective of fairly long focal length. The difference in the amount of light actually picked up and used by the objective in the two different cases is shown in Figures 116 and 117.

Having the condenser a somewhat longer distance behind the aperture is generally a desirable feature, allowing the operator more room for working between the lamp housing and machine.

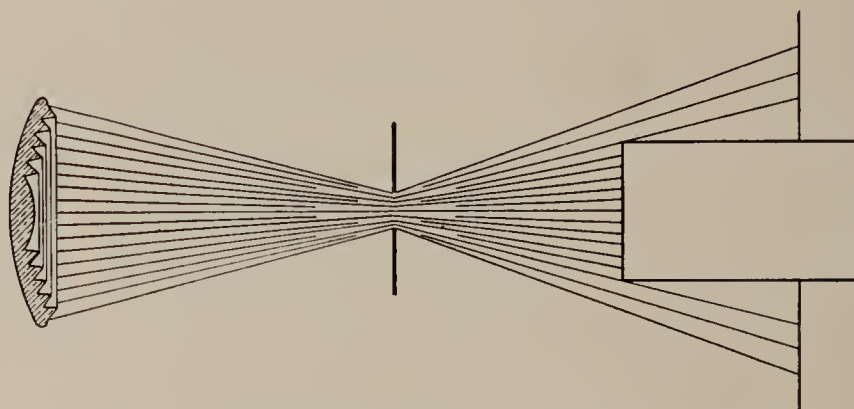


Fig. 117—Corrugated Condenser Showing Short, Wide Cone of Light

Motion picture machines which are equipped with corrugated condensers require a separate plano-convex lens combination, to be quickly slipped into place whenever lantern slides are to be shown, necessitating, of course, a mechanism for rapid and easy change-over of condensers. In this connection it should be noted that when the plano-convex condenser is used for alternate motion picture and lantern slide projection, the slide-holder should not be allowed to remain in front of the condenser while motion pictures are being shown, as this will reduce the total light on the screen to quite an appreciable extent.

Proper Distances From Lamp to Condenser, and Condenser to Aperture: The distance between lamp and condenser and between condenser and aperture for best projection will vary somewhat, depending on the sizes of condensers and objectives used. Table II shows the best practice for the different combinations.

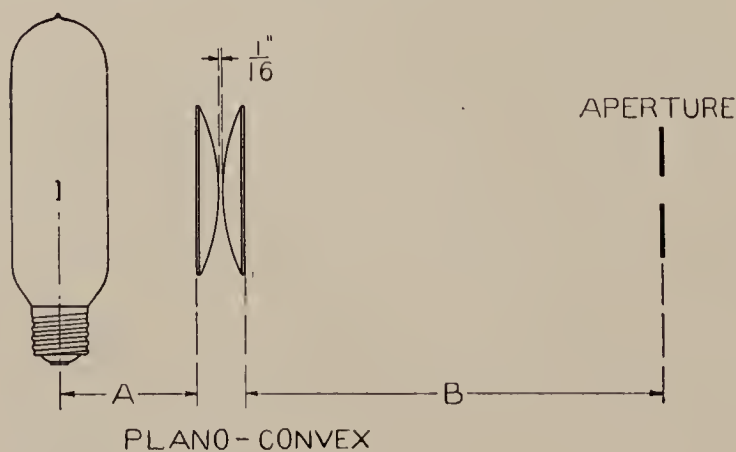


Fig. 118

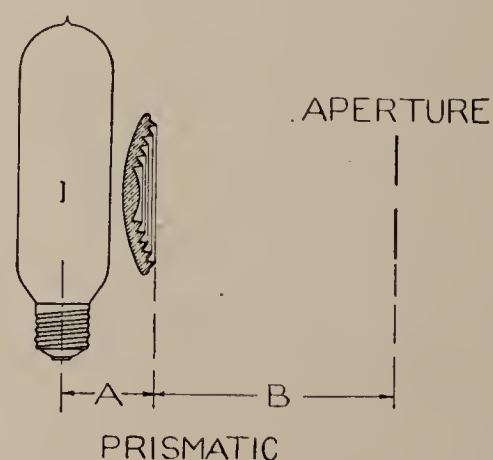


Fig. 119

TABLE II
BEST SOURCE-CONDENSER AND CONDENSER-APERTURE
DISTANCES

OBJECTIVE		CONDENSER	DISTANCE RECOMMENDED	
SIZE	FOCUS		A	B
No. 1	3 1/2"	6 1/2" x 7 1/2" plano-	4"	8 3/4"
No. 1	5 1/2"	" " convex	3 5/8"	9 3/4"
No. 1	6 1/2"	" "	3 5/8"	9 3/4"
No. 2	5 1/2"	" "	3 3/4"	10 1/2"
No. 2	6 1/2"	" "	3 5/8"	11"
No. 2	10"	" "	3 5/8"	11"
No. 1	5 1/2"	6 1/2" x 6 1/2" plano-	3 1/2"	8 3/4"
No. 2	5 1/2"	" " convex	3 1/2"	8"
No. 2	6 1/2"	" "	3 1/2"	8 1/4"
No. 2	10"	" "	3 1/2"	8 3/4"
All sizes		2 1/2" x 6 1/2" prismatic	2 1/2"	6 1/2"

The distance B is measured to the position of the film at the aperture. Tests with the prismatic condenser show that slightly more light can be thrown on the screen by increasing B above the value shown, but this is done at the expense of screen uniformity.

CORRUGATED CONDENSER SYSTEM

In an attempt to combine in one lens the advantage of a two-lens system and at the same time eliminate the disadvantages of the latter as much as possible, the corrugated or modified Fresnel lens has been designed. A photograph of this lens is shown in Figure 120. The primary

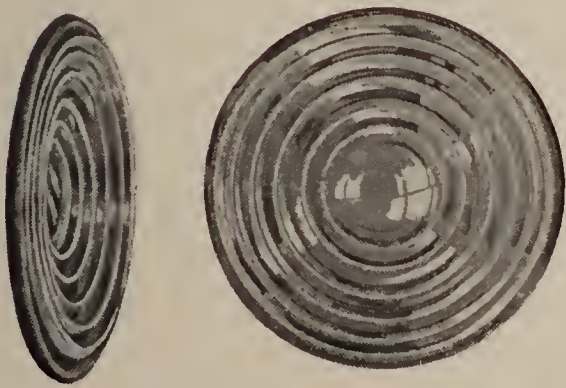


Fig. 120 —Corrugated Lenses

principle of its design is a modification of a very thick lens convex on both sides. As has already been explained, the errors in such a thick lens due to spherical aberration would be great. In order to overcome these errors as much as possible the corrugated lens has been designed, similar to the thick double convex lens shown in Figure 112, page 8, but with the exception that a large part of the glass, especially near the center of the lens, has been eliminated. As will be seen from the illustration, the general appearance of

the corrugated lens is that of a small bull's-eye in the center, surrounded by a series of concentric prisms. Incidentally it has been claimed by some that the design of the concentric prisms is such that different rings illuminate different portions of the film, producing a more uniform illumination. However, this condition is practically the same as that produced by spherical aberration and is, therefore, not peculiar to the corrugated lens. An attempt to carry this feature too far will defeat its own purpose and actually make the illumination of the film less rather than more uniform.

A larger angle of the light from the filament of the lamp is intercepted by this lens, as was explained in the section on the plano-convex condenser.

Whenever light passes from air into glass or from glass into air there is a certain loss due to reflection. Obviously, when there is only one lens and consequently only one passage of light from air into glass and from glass into air, the reflection loss is less than it would be were two lenses used. On the other hand, in the corrugated lens there is that loss due to light striking the risers of the prisms, and striking obliquely on the convex face as previously explained.

The distance between corrugated condenser and aperture is short, producing a fairly wide cone of light which must be intercepted by the objective. Except where half-size short focus objectives are used, this wide cone of light cannot be fully utilized.

The corrugated condenser must be carefully adjusted or rings of light will be thrown on the screen, and even with the best possible adjustment the corrugated condenser is not suitable for the projection of slides due to the fact that in such work these same rings stand out very prominently on the screen. When it is desired to show slides, a plano-convex condenser lens must be substituted.

ASPHERIC LENS SYSTEM

As was explained, a very thick double convex lens will produce large errors due to spherical aberration. This is from the fact that light which passes through the edge of the condenser is bent inward too much in comparison with light which passes nearer the center.

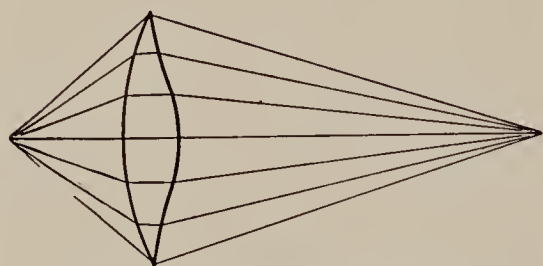


Fig. 121—Aspheric Condenser

In order to overcome this defect several types of aspheric lens have been designed. The curvature of one surface is such that the lens is flattened near the edge by just the proper amount to compensate for spherical aberration. This aspheric or non-spherical surface is placed toward the front

while the rear surface of the lens is of the ordinary spherical curvature. This lens can be built of glass which, in spite of the thickness, is not easily cracked due to heating and consequently can be placed quite close to the lamp. There is, of course, a considerable loss in light due to reflection from the rear surface of this condenser. One of the particular troubles with this lens has been the difficulty in grinding the aspheric surface, now being overcome to a considerable extent.

PARABOLIC CONDENSER SYSTEM

This lens system comprises two lenses ground with special parabolic curves designed to control the light more accurately and efficiently than can be done with the common spherical surface lens. One projector manufacturer is supplying a metal spherical reflector instead of the usual glass reflector with the parabolic condensers. The object of using a metal reflector is to eliminate the light ordinarily lost in passing through the glass to the back surface and then forward through the glass in the common type of mirror.

MENISCUS PLANO-CONVEX CONDENSER SYSTEM

This is a system which is rarely used on the standard size machines, largely on account of its complexity. It consists of three separate lenses, as shown in Figure 122.

That nearest the lamp is known as the meniscus lens. The

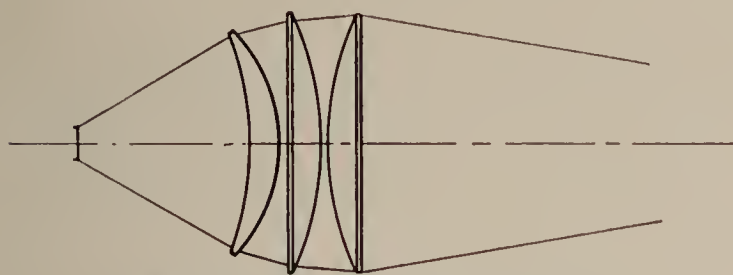


Fig. 122—Meniscus Plano-Convex Condenser System

that with three lenses, each one of them has to bend the light only a comparatively small amount, so that thinner lenses can be used, and spherical aberration is at a minimum. As has been explained before, there is an appreciable loss of light by reflection every time light passes into or out of glass, and the introduction of the third lens into the projection system increases this loss. This reduction in efficiency just about offsets any gain which may be accomplished due to other features of this system.

There are a number of other condensing lens systems which have been invented and are very interesting from the scientific standpoint, but as none of them are at present of any commercial value, time will not be taken to describe them here.

APERTURE

Size: The aperture, as has been mentioned before, is simply an opening of the proper size and shape in a metal plate. The aperture which has been recommended by the Society of Motion Picture Engineers and generally accepted as standard is a rectangle 0.6795-inch high by 0.906-inch wide, with corners slightly rounded. This opening is exactly three-quarters as high as it is wide and, therefore, any picture which is projected on the screen through a standard aperture will always be of this relative proportion.

Magnification: The aperture must have sharp clean-cut edges in order to produce on the screen a straight smooth frame for the picture. Some idea of the required accuracy in the film aperture and in the film itself may be gained by realizing that the aperture and the pictures on the film are so magnified that when, for instance, a 12-foot by 16-foot picture is shown, the area of the screen picture is about 45,000 times the area of the film picture.

Intensity of Light Beam: It will easily be seen, also, that in order to produce a certain intensity of light on the screen there must be approximately 45,000 times this intensity in the beam of light which passes through the aperture. As a matter of fact, the required intensity of the beam is much greater than this because even the best objective lens absorbs about 30% of the light in the beam while the rotating shutter cuts off about 50% of the remainder. In view of this loss, it is actually necessary that the intensity of light in the beam be 125,000 times the intensity of the light on the screen. These figures apply to the projection of a 12 by 16-foot picture. For larger or smaller pictures this ratio will change accordingly.

Most Efficient Size of Light Source: One of the difficulties in producing a beam of light of this high intensity is the fact that the lamp or source of light must be not only very powerful but it must give out this tremendous volume of light from a very small area.

other two are of the ordinary plano-convex type. It should be noted that the plano-convex lenses should be of larger diameter than the meniscus in order for the greatest possible amount of light to be utilized. The principal advantage of this system is

Referring to Figure 123, it will be seen that practically all the light which comes from the source between the limits A, A¹ and passes through the condensing lens will also pass through the aperture. However, light

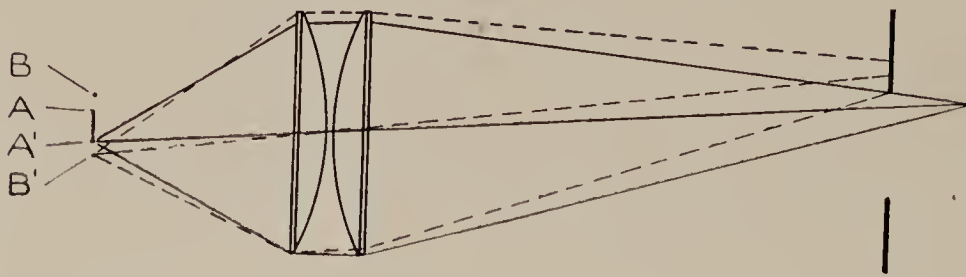


Fig. 123—Showing How Size of Efficient Light Source is Limited

which comes from positions B or B¹ or from any point beyond these limits and passes through the condensing lens system will strike the aperture plate and be a total loss. Light which comes from points be-

tween A and B, or between A¹ and B¹ will suffer a partial loss. Some of it will strike the aperture plate and some pass through, depending on the part of the condenser through which it is transmitted.

Since the lamp filament or other source of light forms an image of itself at or near the aperture, the source which would have the greatest projection efficiency would be one which is of exactly the same shape as the aperture. Experience has shown that the most efficient size of light source for a standard motion picture projection system is one which is approximately 0.43-inch wide. Since the source should conform to the shape of the aperture it should be three-quarters as high as it is wide, or 0.32-inch high. As a matter of fact, the filament of the Mazda motion picture lamp is approximately the width prescribed here, but it is somewhat higher than 0.32-inch, and is built in this way because the top and bottom turns of filament wire are necessarily a little cooler than the center section, due to their contact with lead-in wires and filament supports. With this construction a powerful and brilliant source of light is obtained of the proper size and shape to produce the most efficient projection.

SPHERICAL MIRROR

Importance of Mirror: The spherical mirror plays a very important part in projection with Mazda lamps because it greatly increases the amount of light which can be utilized.

Figure 124 shows a typical mirror for use in motion picture projection with Westinghouse Mazda lamps. The silvered surface of this mirror, as its name implies, is of spherical curvature, such that when properly adjusted it possesses the property of throwing an image of an object placed at its center of curvature directly back upon that object. When used with a Mazda motion picture lamp, such a mirror can be made to throw the filament image directly back upon the filament, but in practice the image is slightly offset so that it will fill in the spaces between the sections of the actual filament, thus producing what practically amounts to a solid wall of light of fairly uniform intensity and of the proper size and shape.



Fig. 124—Typical Commercial Type Mirror

Mirror Sizes: In order to obtain the greatest possible amount of useful light from the mirror of the type described, it is necessary that the mirror intercept a slightly greater angle of light from the filament than is intercepted by the condensing lens system.

The size of the mirror is not of so much importance as the angle of light from the source which it intercepts. Figure 127 shows two mirrors differing considerably in diameter but intercepting the same angle of light from the lamp, and both of these mirrors will produce the same effect as projection of the picture is concerned. The advantage in using the large mirror consists entirely in the fact that it can be placed farther from the lamp and, being cooler during operation than the smaller one, will consequently have a longer life.

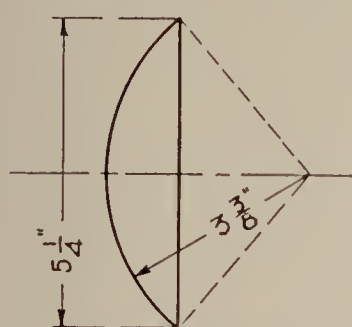


Fig. 126
Typical Commercial
Type Mirror

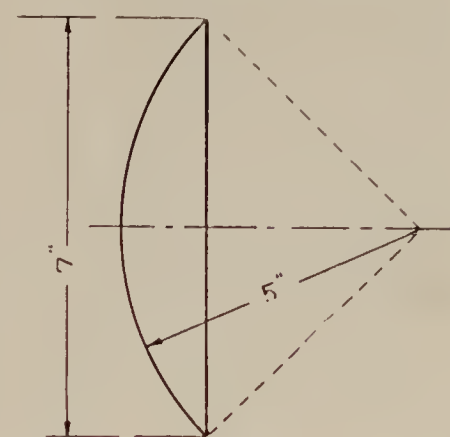


Fig. 125
Typical Commercial
Type Mirror

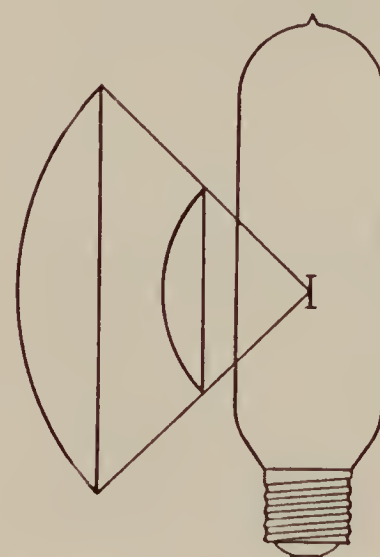


Fig. 127—Showing How Two
Mirrors of Different Sizes
Can Intercept the Same
Angle of Light



Fig. 128-A
Lamp Filament
Lighted With No
Mirror Image



Fig. 128-B
Mirror Images Cor-
rectly Located

Mirror Images: Figure 128, A to E inclusive, shows the filament without the mirror, the filament and mirror images correctly adjusted, and the filament and mirror images in several incorrect positions. A shows the lamp filament alone. B shows the lamp filament with the mirror image in the correct position. It will be seen in this case that the mirror images are exactly the same size as the filament sections and lie immediately in the openings between the sections, producing a solid bank of light. C shows the filament with mirror images which are too small, when the mirror is too far behind the lamp. D shows the mirror images as too large, when the mirror is too near the lamp. E shows the filament images of the proper size but thrown off to one side so that they do not fill up all the space between the original filament sections. Care should be taken to adjust the mirror properly, as it can readily be seen that improper adjustment



Fig. 128-C
Mirror Images
Too Small

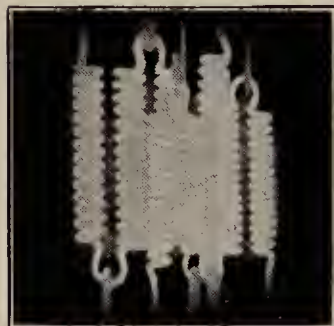


Fig. 128 D
Mirror Images
Too Large



Fig. 128-E
Mirror Images Cor-
rect Size But Off
Center

may very appreciably cut down the amount of useful light, as well as produce a streaked screen.

Light Added by Mirror: The amount of useful light which is added by the mirror depends on two things. The mirror images which are thrown back partly on and partly between the filament sections actually increase the temperature of the filament by a very considerable amount, which naturally results in an increase in the amount of light. The second reason is, of course, the fact that the mirror images become in themselves a source of light of the same nature as the original filament sections. This increase in the useful area and efficiency of the light source is a very substantial one, as shown by the diagram in Figure 129.

Importance of Correct Lamp and Mirror Adjustment: Figure 131 shows the effect of moving the mirror forward or back of the correct position. It will be seen that the illumination on the screen falls off rapidly as the mirror is moved one way or the other and at the same time the appearance of the picture on the screen becomes poorer. If the mirror be slightly out of adjustment it will be seen that the screen uniformity is slightly poorer with the plano-convex condenser than with the corrugated even though the illumination is a little higher.

Figure 130 shows the effect of moving the lamp and mirror as a unit either forward or back of the correct position. Here it will be seen that, when using the corrugated lens, the screen illumination drops rapidly as the lamp and mirror are moved forward. When moved back, the illumination rises slightly but the appearance of the screen picture immediately becomes unsatisfactory. It is not desirable, therefore, to operate with this latter adjustment. In the plano-convex lens system as the lamp and mirror are moved forward or back, the illumination drops somewhat though the appearance of the screen is, in general, better than with the corrugated lens.

It is thus most important to see that the correct adjustment is made whenever a new lamp is placed in the housing.

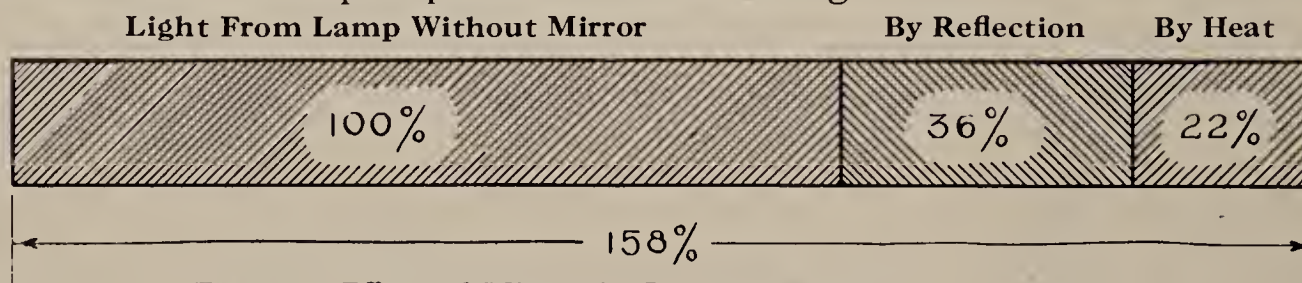


Fig. 129—Effect of Mirror in Increasing Screen Illumination

OBJECTIVE LENS

Sizes: Objective or projection lenses used in motion picture machines are made in two sizes. The smaller of these is known as the one-quarter or No. 1 size. The clear opening through this lens in the case of ordinary focal lengths varies from approximately $1\frac{1}{2}$ to $1\frac{3}{4}$ inches according to the make of the lens. The outside diameter of the metal tube is approximately $1\frac{15}{16}$ inches.

In cases of focal lengths under $3\frac{1}{2}$ inches or thereabouts, it is usually necessary to cut down this clear opening appreciably, since short focus lenses have a very sharp curvature and must be made small in diameter to keep the thickness within reason. An extremely short focus is needed only where a large picture is required with an unusually short throw.

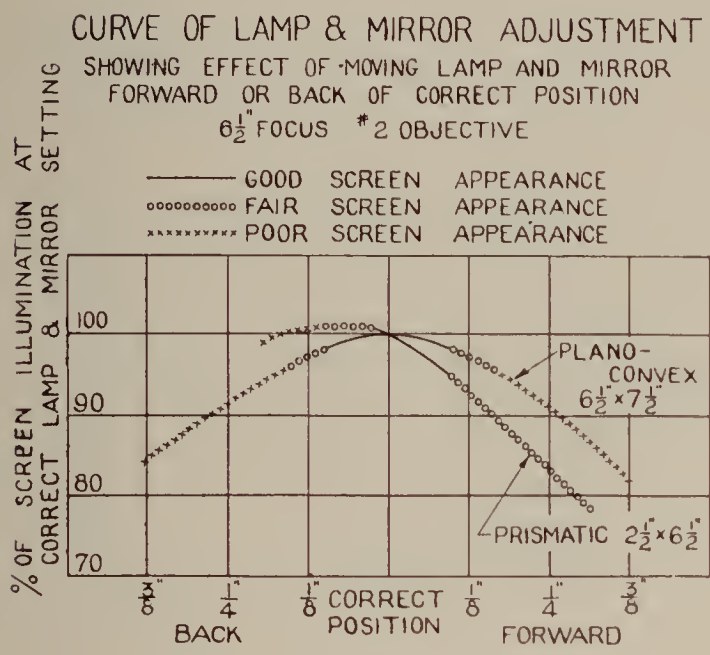


Fig. 130

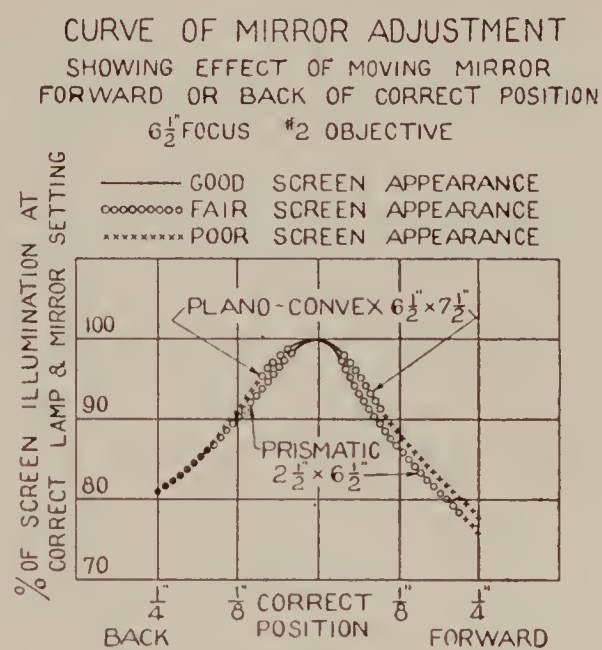


Fig. 131

The larger lens is known as the one-half or No. 2 size. The clear opening through this lens varies from approximately $2\frac{7}{16}$ to $2\frac{1}{2}$ inches. The outside diameter of the complete lens in this case is about $2\frac{3}{4}$ inches. Suitable adapters are furnished to fit No. 1 or No. 2 size lenses to all standard makes of projectors.

Objective lenses are now obtainable in the following sizes:

- (a) Quarter size or No. 1 projection lenses in any focal length from 2 to 8 inches, graded in quarter inches.
- (b) Half size or No. 2 projection lenses in any focal length from $4\frac{1}{2}$ to 12 inches, graded in quarter inches. The proper lens to use for a given projection distance and size of picture is specified on page 20.

Figures 132 and 133 show some of the more common types of objective lenses used for motion picture work.

Large Lenses Give Brighter Pictures: The sketches, Figure 134, and Figure 116, page 10, show the increased amount of light which can be



Fig. 132—Typical Motion Picture Objective or Projection Lenses



Fig. 133—Long Focus Stereopticon Objective (Left) and Short Focus Motion Picture Objective (Right)

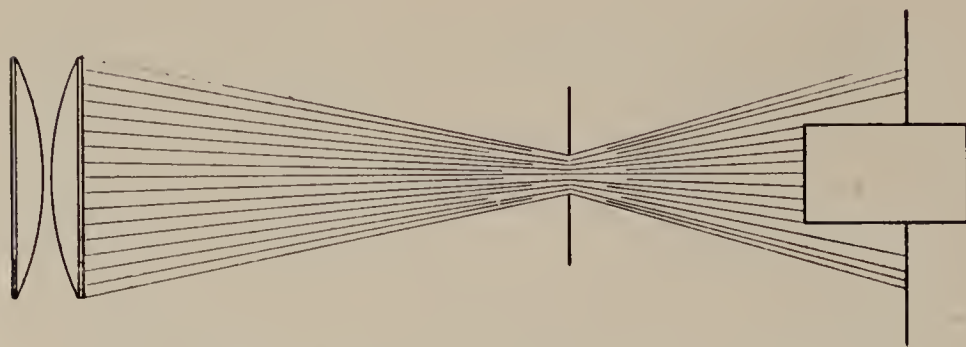


Fig. 134—Showing Light Lost When No. 1 Objective is Used. Compare With Fig. 104.

collected and used by the half size lens as compared with that of the quarter size. The brighter appearance of the screen with the larger lens, contrasted with the appearance when the

smaller lens is used, demonstrates this fact very strikingly.

In past years considerable difficulty has been experienced in manufacturing the half size lenses with sufficient accuracy to produce satisfactory sharp pictures on the screen. This has been true particularly in the lenses of shorter focal lengths. Recently, however, considerable progress has been made along this line and it is now possible to obtain very satisfactory half size lenses in focal lengths as short as $4\frac{1}{2}$ inches. Usually any very considerable increase of light on the screen, such as can be obtained by substituting a large lens for a small one, is extremely desirable and will amply compensate for the difference in first cost of the lens. In the rare cases where this higher screen illumination is not desired, the half size lens will still be found a very attractive investment due to the fact that it makes possible the use of a lower wattage lamp.

ROTARY SHUTTER

General Use: The rotary shutter is mounted in the position shown at S, Figure 105, page 6. This shutter cuts off the light from the screen during the period while the film is moving past the aperture and allows the light to pass through to the screen only while the film is held stationary with the picture in position at the aperture.

Two Blade Type: Several types of rotary shutter are shown in Figures 136, 135, 137. In order to project the picture only while the film is stationary, it is true that a shutter with but one blade would suffice. However, at the speed at which pictures are shown, namely, sixteen per second, this produces a very noticeable flicker. The more rapidly the beam of light is interrupted, the less noticeable will be this flicker. Consequently a very common type of shutter is the one shown in Figure 136 having two blades, one of which serves the purpose of cutting off light from the screen while the film is in motion, while the other blade interrupts the beam in the middle of the period during which a single picture is being shown. With this shutter, the light is interrupted thirty-two instead of sixteen times per second, and the flicker effect is nearly eliminated.

Three-Blade Type: Another shutter which is very largely used, is the three-wing type shown in Figure 136. This possesses the advantage of interrupting the light three times at each revolution and the result is a complete elimination of flicker. It is important to note that the three-wing shutter can be operated on a D. C. arc machine but not with an A. C. arc, because when used with the latter, the interruptions of the arc, due to the alternating current, combine with the interruptions of the beam caused by the three-wing shutter in such a way that the picture on the screen varies noticeably in brightness.



Fig. 135—Perforated Blade Shutter

appear white. This resembles the perforated shutter in one respect, namely, that a certain amount of light is projected on the screen while the film is in motion, and during the intermediate cut-off periods when the film is standing still.

Double Shutter: Another type not shown here consists in reality of two shutters rotating in opposite directions. The purpose of this arrangement is to cut down the time required

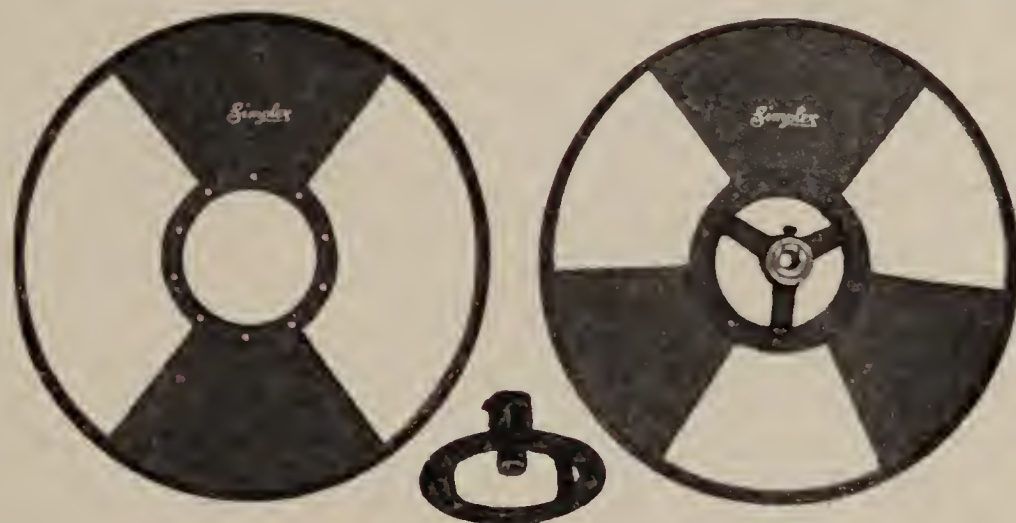


Fig. 136—Typical Two and Three Blade Shutters

to completely obscure the objective lens. With two shutters, it is possible to eclipse the beam in a short space of time and consequently allow a slightly longer interval for the actual projection of each picture. The practical effect of this increase, however, is not sufficient to warrant the use of the more complicated shutter mechanism.

The focal length of the objective lens for a given combination of projection distance and picture size is shown in the table on page 20.

Care of Lenses and Mirror: Condenser lenses, objective lens, lamp and mirror should be dusted off every day, as a small amount of dust will noticeably reduce the picture brightness. Do not touch the lenses with the fingers, since greasy marks may result.

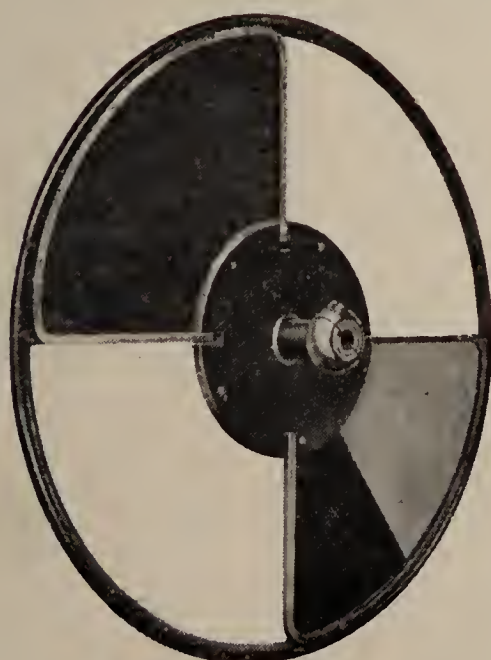


Fig. 137—Three Color Rotary Shutter

Equivalent Focus in Inches	PROJECTION TABLE											
	For Standard Size Motion Picture Aperture 0.6795 in. x 0.906 in. Distance from Film to Center of Screen											
	Picture	20 ft.	30 ft.	40 ft.	50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.	110 ft.	120 ft.
2	Height	6'-9"	10'-1"	13'-6"	.....	.....	.....	.....	.....	.....	.....	.....
	Width	9'-0"	13'-7"	18'-1"	.....	.....	.....	.....	.....	.....	.....	.....
2¼	Height	6'-0"	9'-0"	12'-0"	15'-0"	.....	.....	.....	.....	.....	.....	.....
	Width	8'-0"	12'-0"	16'-1"	20'-1"	.....	.....	.....	.....	.....	.....	.....
2½	Height	5'-5"	8'-1"	10'-10"	13'-6"	.....	.....	.....	.....	.....	.....	.....
	Width	7'-2"	10'-10"	14'-5"	18'-1"	.....	.....	.....	.....	.....	.....	.....
2¾	Height	4'-11"	7'-4"	9'-10"	12'-4"	14'-9"	.....	.....	.....	.....	.....	.....
	Width	6'-6"	9'-10"	13'-2"	16'-5"	19'-9"	.....	.....	.....	.....	.....	.....
3	Height	4'-6"	6'-9"	9'-0"	11'-3"	13'-6"	15'-10"	.....	.....	.....	.....	.....
	Width	6'-0"	9'-0"	12'-0"	15'-1"	18'-1"	21'-1"	.....	.....	.....	.....	.....
3¼	Height	4'-2"	6'-3"	8'-4"	10'-5"	12'-6"	14'-7"	.....	.....	.....	.....	.....
	Width	5'-6"	8'-4"	11'-1"	13'-11"	16'-8"	19'-6"	.....	.....	.....	.....	.....
3½	Height	3'-10"	5'-9"	7'-9"	9'-8"	11'-7"	13'-6"	.....	.....	.....	.....	.....
	Width	5'-2"	7'-9"	10'-4"	12'-11"	15'-6"	18'-1"	.....	.....	.....	.....	.....
3¾	Height	3'-7"	5'-5"	7'-2"	9'-0"	10'-10"	12'-8"	14'-5"	.....	.....	.....	.....
	Width	4'-9"	7'-2"	9'-7"	12'-0"	14'-5"	16'-10"	19'-3"	.....	.....	.....	.....
4	Height	3'-4"	5'-1"	6'-9"	8'-5"	10'-2"	11'-10"	13'-6"	15'-3"	.....	.....	.....
	Width	4'-6"	6'-9"	9'-0"	11'-3"	13'-7"	15'-10"	18'-1"	20'-4"	.....	.....	.....
4¼	Height	3'-2"	4'-9"	6'-4"	7'-11"	9'-6"	11'-2"	12'-9"	14'-4"	.....	.....	.....
	Width	4'-3"	6'-4"	8'-6"	10'-7"	12'-9"	14'-11"	17'-0"	19'-2"	.....	.....	.....
4½	Height	3'-0"	4'-6"	6'-0"	7'-6"	9'-0"	10'-6"	12'-0"	13'-6"	15'-0"	.....	.....
	Width	4'-0"	6'-0"	8'-0"	10'-0"	12'-0"	14'-1"	16'-1"	18'-1"	20'-1"	.....	.....
4¾	Height	2'-10"	4'-3"	5'-8"	7'-1"	8'-6"	10'-0"	11'-4"	12'-10"	14'-3"	.....	.....
	Width	3'-9"	5'-8"	7'-7"	9'-6"	11'-5"	13'-4"	15'-3"	17'-1"	19'-0"	.....	.....
5¼	Height	2'-8"	4'-0"	5'-5"	6'-9"	8'-1"	9'-6"	10'-10"	12'-2"	13'-6"	14'-11"	.....
	Width	3'-7"	5'-5"	7'-2"	9'-0"	10'-10"	12'-8"	14'-5"	16'-3"	18'-1"	19'-11"	.....
5½	Height	2'-6"	3'-10"	5'-2"	6'-5"	7'-9"	9'-0"	10'-4"	11'-7"	12'-11"	14'-2"	.....
	Width	3'-5"	5'-2"	6'-10"	8'-7"	10'-4"	12'-0"	13'-9"	15'-6"	17'-3"	18'-11"	.....
5½	Height	2'-5"	3'-8"	4'-11"	6'-2"	7'-4"	8'-7"	9'-10"	11'-1"	12'-4"	13'-6"	14'-9"
	Width	3'-3"	4'-11"	6'-6"	8'-2"	9'-10"	11'-6"	13'-2"	14'-9"	16'-5"	18'-1"	19'-9"
5¾	Height	2'-4"	3'-6"	4'-8"	5'-10"	7'-0"	8'-3"	9'-5"	10'-7"	11'-9"	12'-11"	14'-1"
	Width	3'-1"	4'-8"	6'-3"	7'-10"	9'-5"	11'-0"	12'-7"	14'-2"	15'-9"	17'-3"	18'-10"
6	Height	2'-3"	3'-4"	4'-6"	5'-7"	6'-9"	7'-11"	9'-0"	10'-2"	11'-3"	12'-5"	13'-6"
	Width	3'-0"	4'-6"	6'-0"	7'-6"	9'-0"	10'-6"	12'-0"	13'-7"	15'-1"	16'-7"	18'-1"
6¼	Height	2'-2"	3'-3"	4'-4"	5'-5"	6'-6"	7'-7"	8'-8"	9'-9"	10'-9"	11'-11"	13'-0"
	Width	2'-10"	4'-4"	5'-9"	7'-2"	8'-8"	10'-1"	11'-7"	13'-0"	14'-5"	15'-11"	17'-4"
6½	Height	2'-1"	3'-1"	4'-2"	5'-2"	6'-2"	7'-3"	8'-4"	9'-4"	10'-5"	11'-5"	12'-6"
	Width	2'-9"	4'-2"	5'-6"	6'-11"	8'-4"	9'-9"	11'-1"	12'-6"	13'-11"	15'-3"	16'-8"
6¾	Height	2'-0"	3'-0"	4'-0"	5'-0"	6'-0"	7'-0"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"
	Width	2'-8"	4'-0"	5'-4"	6'-8"	8'-0"	9'-4"	10'-8"	12'-0"	13'-5"	14'-9"	16'-1"
7	Height	1'-11"	2'-10"	3'-10"	4'-10"	5'-9"	6'-9"	7'-9"	8'-8"	9'-8"	10'-8"	11'-7"
	Width	2'-6"	3'-10"	5'-2"	6'-5"	7'-9"	9'-0"	10'-4"	11'-7"	12'-11"	14'-2"	15'-6"
7¼	Height	.....	2'-9"	3'-8"	4'-8"	5'-7"	6'-6"	7'-5"	8'-5"	9'-4"	10'-3"	11'-2"
	Width	.....	3'-8"	4'-11"	6'-2"	7'-5"	8'-8"	9'-11"	11'-2"	12'-5"	13'-8"	14'-11"
7½	Height	.....	2'-8"	3'-7"	4'-6"	5'-5"	6'-3"	7'-2"	8'-1"	9'-0"	9'-11"	10'-10"
	Width	.....	3'-7"	4'-9"	6'-0"	7'-2"	8'-5"	9'-7"	10'-10"	12'-0"	13'-3"	14'-5"
7¾	Height	.....	2'-7"	3'-6"	4'-4"	5'-3"	6'-1"	7'-0"	7'-10"	8'-9"	9'-7"	10'-6"
	Width	.....	3'-6"	4'-8"	5'-10"	7'-0"	8'-2"	9'-4"	10'-6"	11'-8"	12'-10"	14'-0"
8	Height	.....	2'-6"	3'-4"	4'-2"	5'-1"	5'-11"	6'-9"	7'-7"	8'-5"	9'-3"	10'-2"
	Width	.....	3'-4"	4'-6"	5'-7"	6'-9"	7'-11"	9'-0"	10'-2"	11'-3"	12'-5"	13'-7"
8½	Height	.....	2'-4"	3'-2"	3'-11"	4'-9"	5'-7"	6'-4"	7'-2"	7'-11"	8'-9"	9'-6"
	Width	.....	3'-2"	4'-3"	5'-3"	6'-4"	7'-5"	8'-6"	9'-7"	10'-7"	11'-8"	12'-9"
9	Height	.....	2'-3"	3'-0"	3'-9"	4'-6"	5'-3"	6'-0"	6'-9"	7'-6"	8'-3"	9'-0"
	Width	.....	3'-0"	4'-0"	5'-0"	6'-0"	7'-0"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"
9½	Height	.....	2'-1"	2'-10"	3'-6"	4'-3"	5'-0"	5'-3"	6'-5"	7'-1"	7'-10"	8'-6"
	Width	.....	2'-10"	3'-9"	4'-9"	5'-8"	6'-8"	7'-7"	8'-6"	9'-6"	10'-5"	11'-5"
10	Height	.....	2'-0"	2'-8"	3'-4"	4'-0"	4'-9"	5'-5"	6'-1"	6'-9"	7'-5"	8'-1"
	Width	.....	2'-8"	3'-7"	4'-6"	5'-5"	6'-4"	7'-2"	8'-1"	9'-0"	9'-11"	10'-10"

Where safety standard film is used, aperture 0.551 in. x 0.748 in., multiply above picture heights by 0.810 and picture widths by 0.825 to get size of picture.

PROJECTORS

THE SIMPLEX INCANDESCENT LAMP PROJECTOR FOR MOTION PICTURES

Introductory

This lamphouse can be used with the plano-convex condenser system or with the parabolic condenser system. The lamphouse and adjusting mechanism are specially constructed for use with the Mazda lamp. Since the housing is not subject to such rigorous heat and service conditions as in the case of the arc, it is possible to build it of lighter material. This housing can be fitted to any standard make of projector through the use of a suitable bed plate.

For current supply the most satisfactory apparatus is the Westinghouse Automatic Current Regulator as this provides a steady flow at all times in spite of the usual supply line fluctuations in voltage.



Fig. 138—Projector Equipped with Simplex Housing for Mazda Lamp

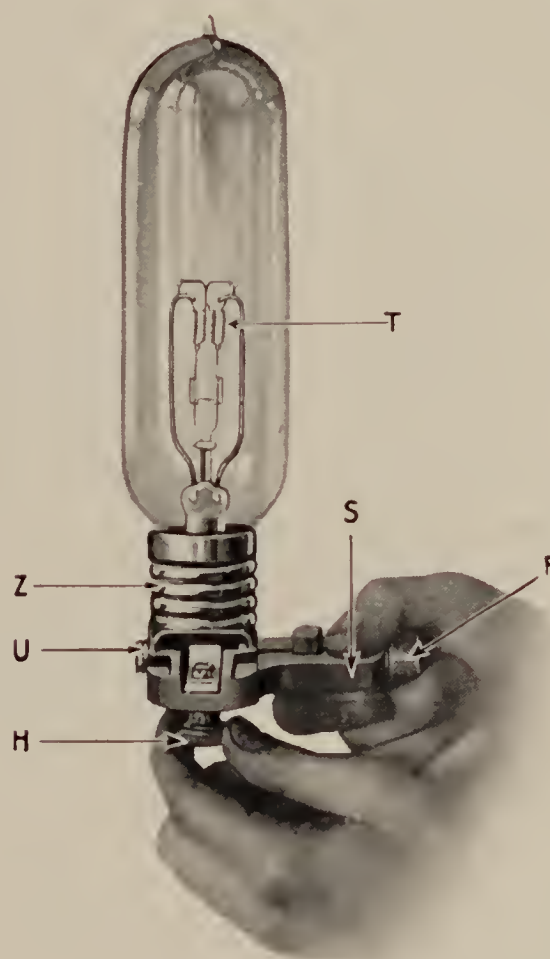


Fig. 139—Simplex Lamp Pre-setting Device With Mazda Lamp

Instructions For Setting Up Equipment

THE CONDENSERS: Condensers J, Figure 141 will be found wrapped with paper covering. Note that sizes of condensers ($6\frac{1}{2}$ inch and $7\frac{1}{2}$ inch) are plainly marked on wrappings.

Unscrew condenser rings M, Figure 141, and drop condensers into same carefully.

Screw condenser holder ring back into place securely enough to hold condenser. Great care must be taken against tightening this ring too firmly, as so doing will bind condenser and prevent expansion when same becomes heated, resulting in possible breakage.

Condenser holders containing condensers are then dropped into containers N, Figure 141, with rounded or convex surfaces facing each other.

Note that the $6\frac{1}{2}$ -inch condenser sets in container nearest the lamp and the $7\frac{1}{2}$ -inch condenser sets in container nearest the film.

Swing condenser mount back into position, locking same by engaging handle 1, Figure 141, with lock K, Figure 141.

PLACING LAMPHOUSE ON MACHINE: Place lamphouse on swinging table, making sure that sliding base P, Figure 141, sets accurately into base groove Q, Figure 141. Fasten lamphouse to base with wing screw R, Figure 141.

SETTING LAMP IN HOLDER: Loosen knob H, Figure 141, turning it out to its fullest extent, then screw lamp O, Figure 141, into its socket, as far as possible.

Adjust lamp so that filament T, Figure 140, is parallel with knob F, Figure 140. This lining up of filament is absolutely necessary to produce correct focus.

Tighten knob H, Figure 141, firmly; this operation rigidly secures lamp into required position, see Figure 139.

INSERTING LAMP AND HOLDER INTO MECHANISM: Lamp and holder are now ready for inserting into lamphouse.

Hold knob F, Figure 139, and thumb piece S, Figure 139, securely between thumb and forefinger of the right hand.

Insert lamp slowly into position, making sure that collar U, Figure 139, engages with rod U-1, Figure 143, and also note that contact strip V, Figure 142, engages between slot and contact holder W, Figure 142. Push lamp in as far as it will go.

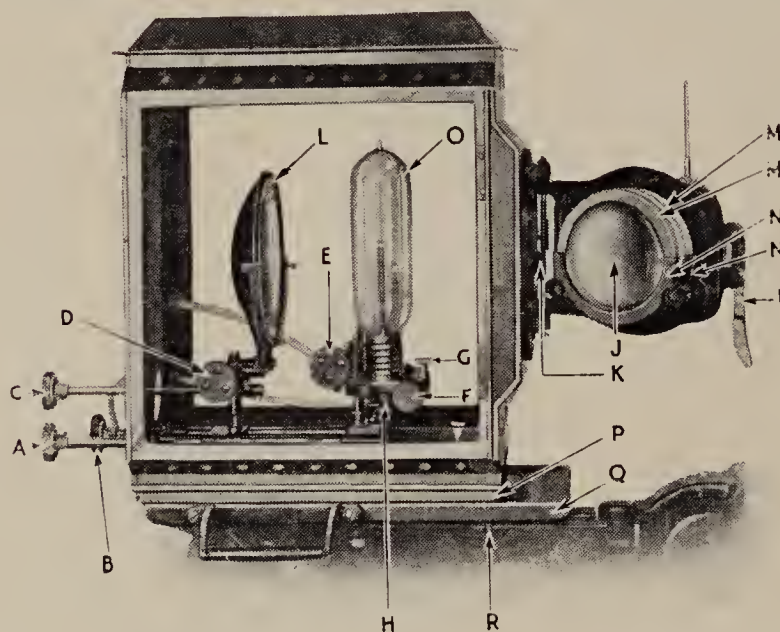


Fig. 141—Simplex Incandescent Lamp Housing Complete

FOCAL DISTANCES: Figure 148 shows the approximate distances between the mirror, the condensers, and the cooling plate of the machine, which should be used.

Should a quarter size $1\frac{3}{4}$ -inch diameter projection lens be used, it is necessary to place ruler against the surface of the $7\frac{1}{2}$ -inch front condenser and move lamphouse slowly forward or backward until a distance of nine inches separates the front condenser surface from the film position or aperture plate on mechanism.

Should the half size $2\frac{5}{8}$ -inch diameter projector lens be used this distance should be increased to eleven inches.

ADJUSTING LAMP: Turn knob B, Figure 141, which is used to carry lamp carriage forward and backward until lamp filament T, Figure 140, is $3\frac{5}{8}$ inches away from flat surface of $6\frac{1}{2}$ -inch rear condenser.

CONNECTING UP APPARATUS: (For alternating current) Connect the apparatus with regulator as shown in Figures 147 or 149.

Note that this diagram is based on voltages ranging from 95 to 120 inclusive.

The ammeter is attached to bracket on rear of lamphouse by means of screws located in bracket, see Figure 147.

WARNING—In no case should ammeter be placed on regulator, as it will not register properly in this location owing to electrical disturbances.

(For direct current) Connect the apparatus as shown in Figure 150. Note that this diagram is based on voltages ranging from 95 to 120 inclusive.

It will be noted that there are two resistance units, one a fixed resistance or "cage type," the other a plate or dial type.

The ammeter is mounted on the dial resistance plate.

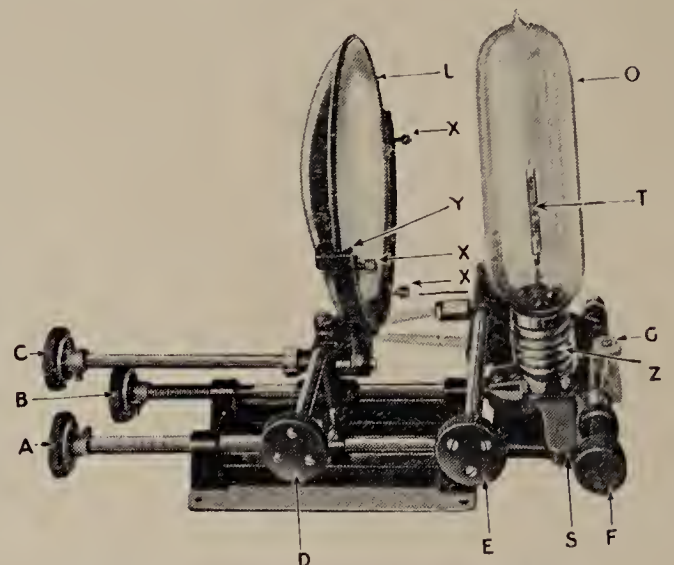


Fig. 140—Simplex Lamp and Mirror Mounting—Side View

INSERTING MIRROR: Polish mirror carefully with clean soft tissue paper.

Loosen thumb screws X, Figure 140, and insert mirror L, Figure 141, carefully into holder Y, Figure 140, tightening thumb screws X, Figure 140, only sufficiently to hold mirror in place without undue pressure.

FOCUSING MIRROR: The distance from the center or back of convex surface of mirror and the filament T-2 of the lamp should be approximately five inches.

This adjustment is made by turning knob A-1 either to the right or left.

Unlock mirror holder by turning knob D-1 to the left.

Swing mirror to one side as far as possible by means of knob C-1, and lock same into position by turning knob D-1 to right. The mirror is thrown to one side to prevent the mirror image being confused with the lamp filament as will be described later.

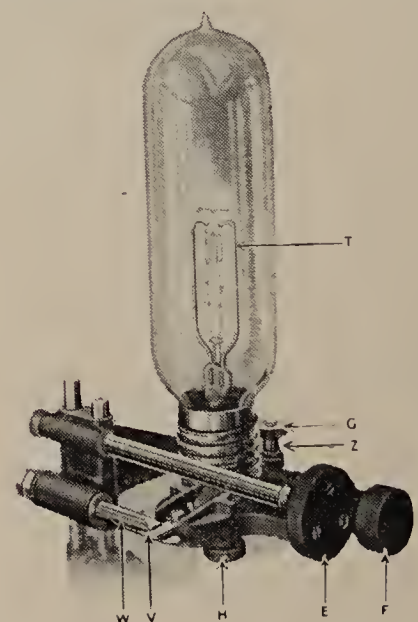


Fig. 142—Presetting Device Being Slid Into Place

Turn regulator handle on dial to the right until it reaches the stop.

Throw the machine switch in and out quickly, or "flash" it, watching ammeter carefully to determine whether it is registering forward or backward.

If ammeter registers backward, disconnect and reverse the two leads on the dial resistance.

After again making the connections secure, repeat the "flash" on the machine switch in order to be assured of the correct polarity.

(For either A. C. or D. C.)

If ammeter registers forward leave machine switch in. The current will jump momentarily to approximately 35 amperes and then drop to about 25 amperes.

The ammeter must be closely watched during the burning period of the lamp and must in no case exceed the rating which is indicated on metal base of lamp.

Lift fire shutter on mechanism and hold it open with a toothpick or match.

Lift dowser on lamphouse hood; this will allow the light to be centered on fire shutter on mechanism, as indicated in Figure 144.

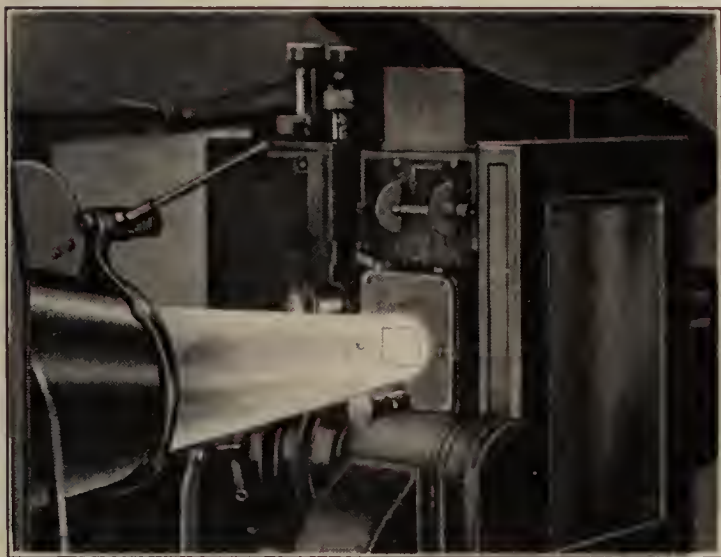


Fig. 144—Centering Spot of Light on Aperture

FOCUSING LAMP FILAMENT ON CARD OR SHUTTER: Remove the projector lens from mechanism and move revolving shutter out on shutter shaft until a distance of $10\frac{1}{4}$ inches separates the cut-off blade on shutter from the aperture plate or film position on mechanism.

Should it not be convenient to use revolving shutter for this purpose, a card may be placed in the same position, making sure, however, that the distance of $10\frac{1}{4}$ inches is maintained.

We now have an image of the lamp filament outlined on the shutter blade or card as indicated in Figure 145. If image is not in exact focus, check up carefully all measurements. If measurements are all correct it is now necessary to sharpen up or focus filament by turning knob B, Figure 141, either to right or left until the filament is clearly outlined upon card or shutter blade.



Fig. 145—Filament Image on Shutter



Fig. 146—Filament and Mirror Images

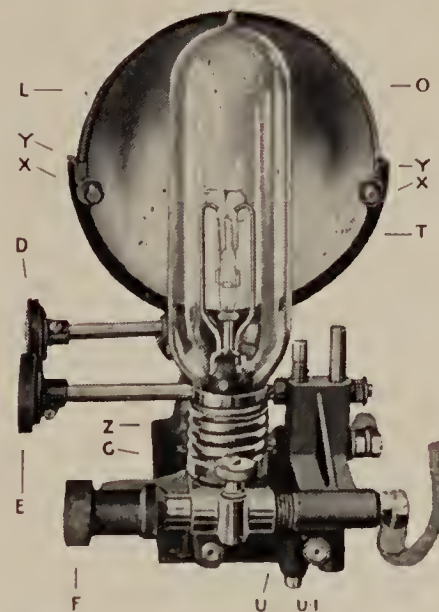


Fig. 143—Lamp and Mirror Mounting—Front View

FOCUSING LAMP: It is necessary that this circle of light shall cut all corners of cooling plate, as shown in Figure 144.

Should the light circle be either too high or too low, adjustment for bringing it into true position is made by operating knob E, Figure 141, and watching results on cooling plate.

Should circle of light be to one side, loosen thumb screw G, Figure 141, then turn knob F, Figure 141 forward or backward as may be necessary until circle of light is in true position on cooling plate.

Should it be necessary in this operation to adjust lamp to left it is necessary to push firmly against knob F-1 in order to produce proper movement of lamp.

LOCKING LAMP: When this adjustment has been satisfactorily made, tighten thumb screw G, Figure 141, securely. This operation locks knob F, Figure 141, preventing lamp from loosely swinging should the lamp holder be taken out.

RESULTS ON FOCUSING CARD OR SHUTTER:

Unlock mirror by turning D-1 to left and swing mirror over by means of knob C-1.

Besides the lamp filament image on the card or shutter, another image may be seen. This is much fainter in definition than the lamp filament image. This faint image is called the mirror image.

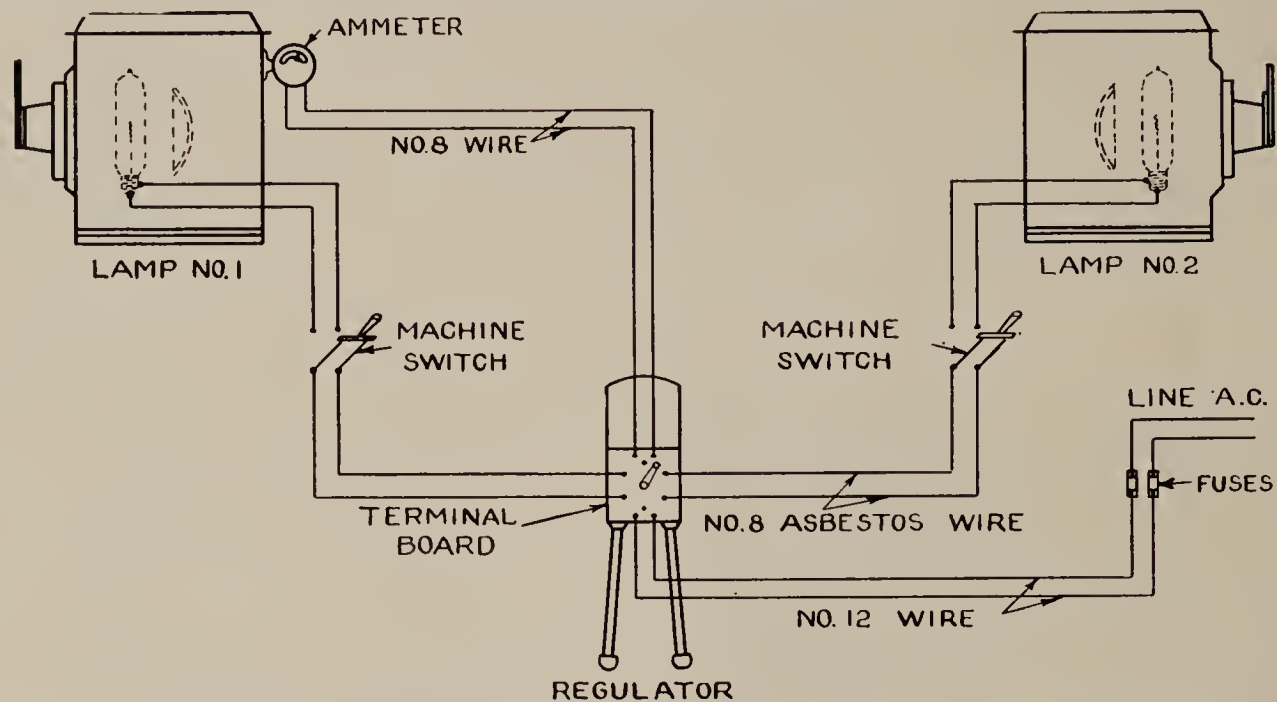
Sharpen this up as much as possible. This is done by adjusting mirror L-1 and turning knob A-1 forward or back.

Center mirror image in same position as the filament image.

Swinging knob C-1 to the side will cause sidewise movement of mirror images.

Should mirror image register too high or too low, turn knob C-1 to right or left.

MERGING BOTH FILAMENTS: If both filaments show up sharp and in position, swing mirror over by means of knob C-1. This will move mirror image over on card or shutter. Register the mirror filament image in between the open spaces of the lamp filament image as shown in Figure 146.



IF USED ON MACHINE EQUIPMENT OMIT NO. 2 CONNECTIONS

WIRING FOR ONE OR TWO LAMPS ON ALTERNATING CURRENT WITH AUTOMATIC REGULATOR

Fig. 147

LOCKING MIRROR: Lock mirror into position by turning knob D, Figure 141, to right.

INCREASING AMPERAGE: (Alternating current) Bring lamp up to full current, 30 amperes, by adjusting regulator.

(Direct current) After the lamp and resistance have become sufficiently warmed up turn the dial handle slowly to the left until the ammeter registers 30 amperes.

WARNING—Do not under any circumstances exceed thirty amperes, as so doing will result in overloading and subsequent damage to lamps.

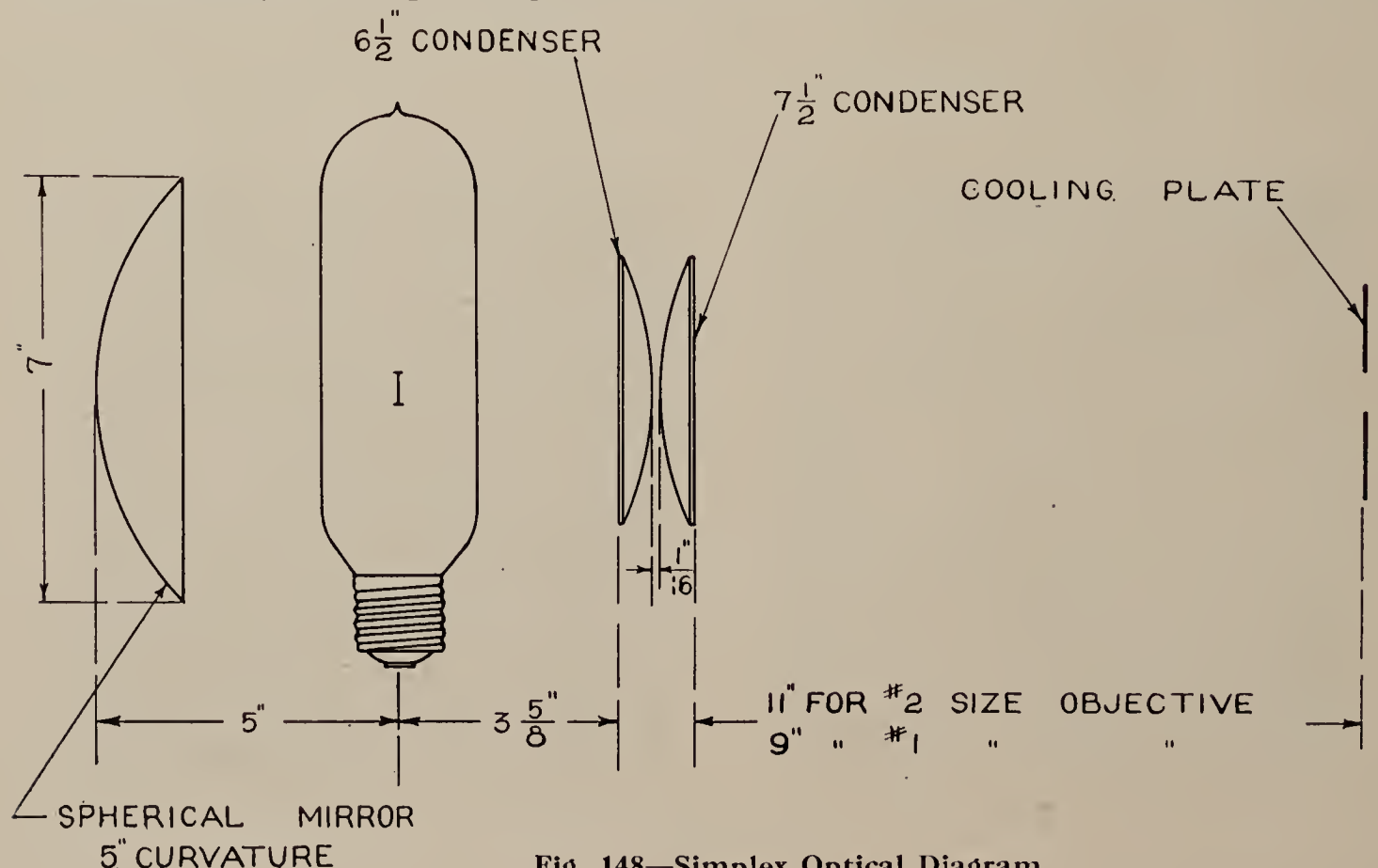


Fig. 148—Simplex Optical Diagram

CLEAR FIELD OF LIGHT: Replace projector lens in mechanism.

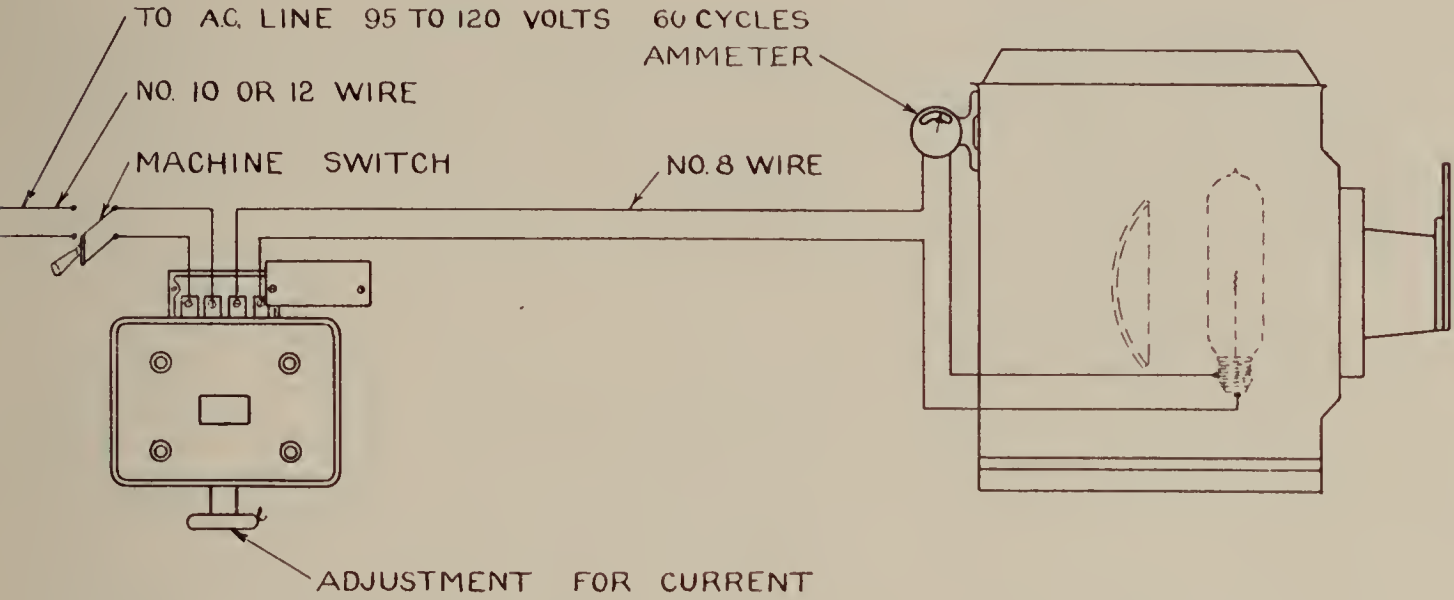
Focus same up sharply.

Screen should now show a clean evenly distributed field of light.

Should any discoloration or shadows be apparent on screen, slide lamphouse carefully and slowly backward or forward until discoloration disappears.

When screen is all cleared up fasten lamphouse by tightening up wing screw R, Figure 141.

Take away focusing card and readjust shutter if necessary, and the equipment is ready for operation.



WIRING FOR SINGLE LAMP ON
ALTERNATING CURRENT WITH HAND REGULATOR

Fig. 149

ADJUSTING EXTRA LAMP: In order to be prepared for any emergency it is wise to have an extra lamp and holder all ready for instant use.

Follow instructions in "Setting Lamp in Holder" and set holder containing lamp to one side where it will be quickly available.

Directions in this Paragraph for Direct Current (For alternating current see next paragraph):

Should same be required while machine is in operation, pull machine switch and withdraw burned out or defective lamp and insert new lamp and holder, as described in "Inserting Lamp and Holder into Mechanism."

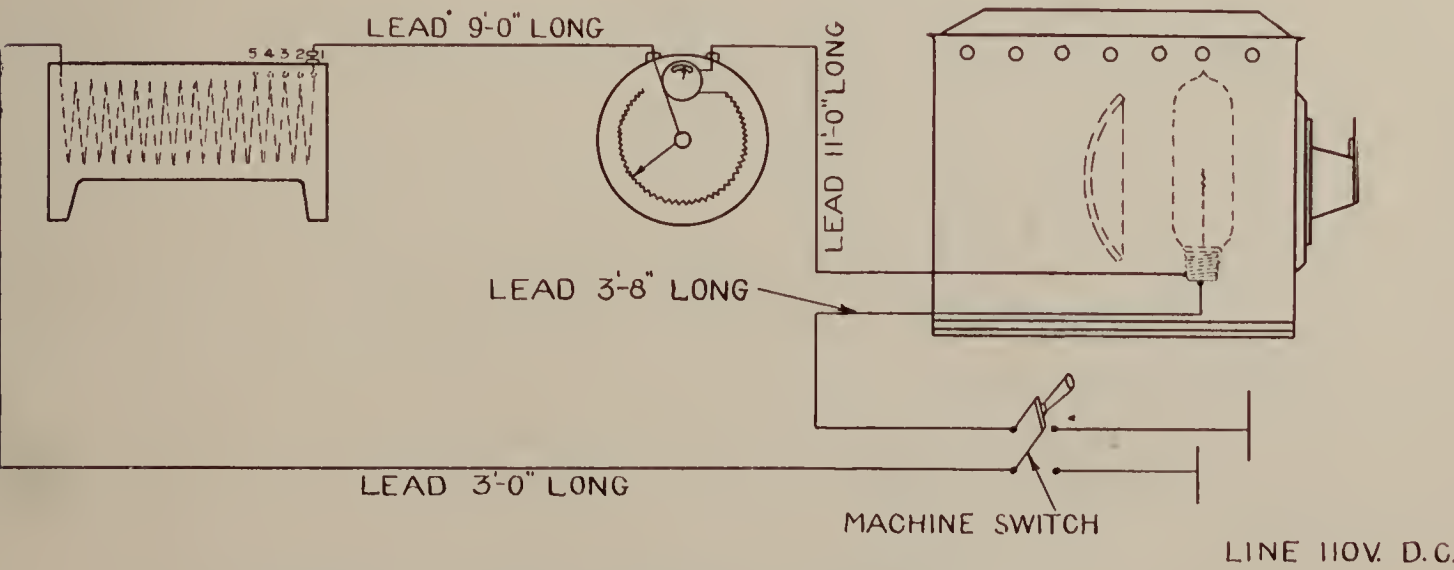
(For alternating current)

Should same be required while machine is in operation, pull machine switch, throw back regulator handle to "LOW," withdraw burned out or defective lamp and insert new lamp and holder, as described above.

CAUTION: Make sure that machine switch is off before withdrawing old lamp.

Throw in machine switch and bring current up to 30 amperes.

Center spot of light on cooling plate as before described and get as clear a field as possible until an opportunity of procuring permanent readjustment is available.



WIRING FOR SINGLE LAMP ON
DIRECT CURRENT WITH RHEOSTAT

Fig. 150

THE G. E. INCANDESCENT LAMP PROJECTOR FOR MOTION PICTURES

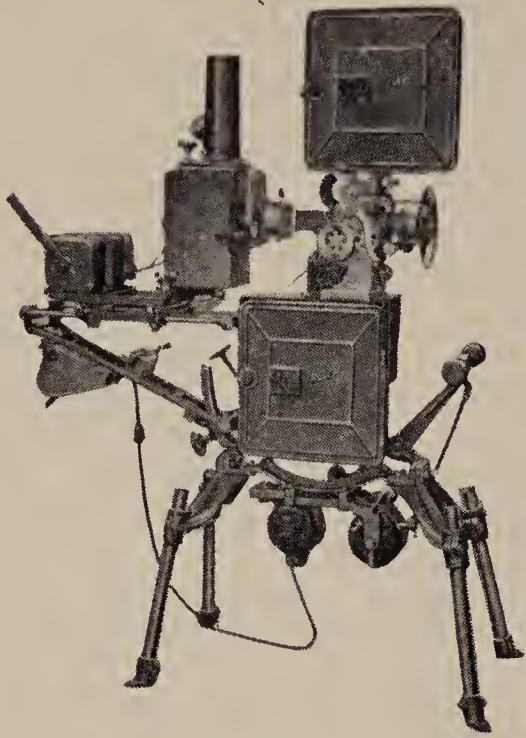


Fig. 151—Projector Equipped With G. E. Housing for Mazda Lamps

After the lamphouse carriage B and its lamphouse A have been placed on the carriage track C-1, replace the carriage motion picture stop C-5 and screw it in tight.

Introductory

This lamphouse uses the prismatic condenser. The housing is small, but ample ventilation is provided to avoid overheating. On the same base with the lamphouse is mounted a hand regulated transformer to supply the proper voltage and current to the lamp. The operator watches the ammeter and moves the transformer regulator handle up or down from time to time to compensate for supply line voltage fluctuations. The housing is equipped with a lamp pre-focusing device. The lamphouse and transformer can be mounted on any standard type motion picture projector.

Assembling

HOW TO ATTACH THE LAMPHOUSE CARRIAGE WITH THE LAMPHOUSE TO THE BASE BRACKET (Figure 156): Remove the carriage motion picture stop C-5 on the base C by unscrewing it. Place the lamphouse carriage B with the lamphouse A attached on the carriage track C-1, making sure that the three carriage rollers B-1, Figure 156 fit in the grooves of the track. It may require considerable force to fit these rollers in the grooves, but when once in place the carriage should slide easily. If the rollers stick, a little vaseline or oil will help greatly.

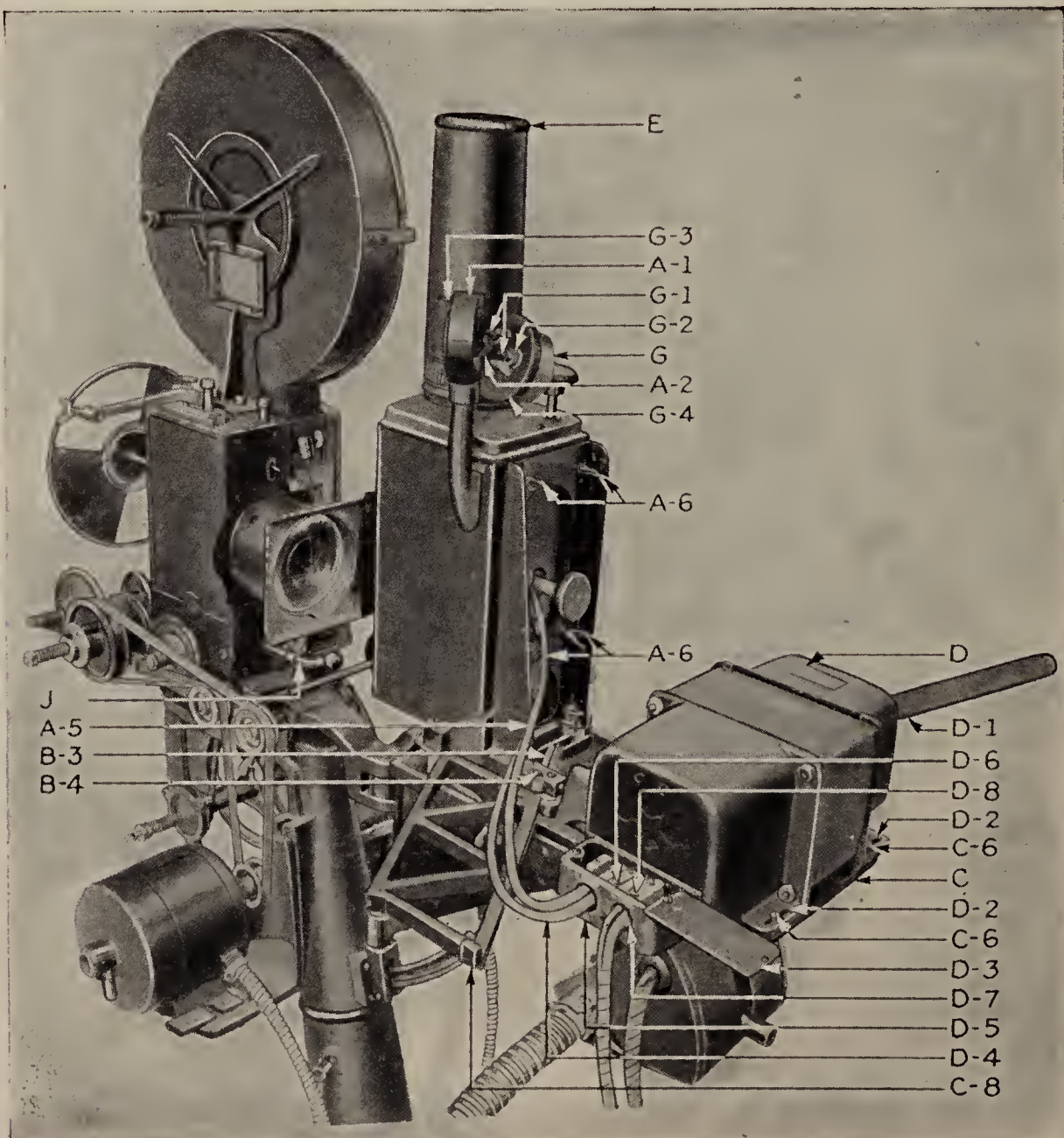


Fig. 152—Assembly of Lamphouse and Regulator on Base.

CHIMNEY ON THE LAMPHOUSE: Next place the chimney E on top of the lamphouse and force the chimney down tight.

HOW TO ATTACH THE AMMETER ON THE LAMPHOUSE: (Figure 152) Connect the two ammeter lead wires A-2 protruding from the ammeter support A-1 attached to the upper part of the lamphouse A to the two large contact screws G-1 projecting from the back of the ammeter G, making sure that the contact nuts G-2 are screwed down tight. Fasten the ammeter G to the ammeter support A-1 with the three long ammeter attaching screws G-3 by screwing them from the back of the ammeter support A-1 into the back plate G-4 of the ammeter G.

REFLECTOR IN THE LAMPHOUSE: Insert the silvered glass spherical reflector H in its holder Q, Figure 156.

HOW TO PUT THE STEREOPTICON OR PLANO-CONVEX CONDENSING LENSES IN STEREOPTICON CONDENSER MOUNT: (Figure 154) Remove the stereopticon condenser holder P-1 from the stereopticon condenser mount P by loosening the clamping screw P-4. Then remove the spring retaining ring P-2 and the spacing ring P-3 from the condenser holder P-1. Take out the two plano-convex condenser lenses (used with the former carbon-arc equipment), which are usually of 6½-inch and 7½-inch focus. Place the thin one or the 7½-inch focus lens in the holder P-1 with the flat side of the lens towards the stereopticon condenser dowser P-5; then insert the spacing ring P-3 and place the thick or the 6½-inch focus lens on top of this with its flat side uppermost. Hold the condensing lenses in place with the spring retaining ring P-2. The condensing lenses should now have their curved sides facing each other, their flat surfaces on the outside.

The stereopticon condenser holder P-1 may now be inserted in the stereopticon condenser mount P. The dowser hinge P-7 should be on the opposite side from the clamping screw P-4 and the screw should be tightened to prevent the condenser holder P-1 from falling out of the mount. The slide carrier P-8 (which should be taken from the former equipment) can now be inserted in place.



Fig. 153—How to Put Motion Picture Condenser Mount on Lamphouse

HOW TO PUT THE STEREOPTICON MOUNT ON THE LAMPHOUSE: The stereopticon condenser mount P should be placed in the condenser guides A-3, Figure 156, inserting it from the far side of the lamphouse, Figure 152.

HOW TO PUT THE MOTION PICTURE CONDENSER MOUNT ON THE LAMPHOUSE: (Figure 153) Attach the two projecting hinges F-1 of the motion picture condenser mount F to the inside of the stereopticon condenser mount P by means of the hinge pin F-2, keeping the motion picture condenser dowser F-3 towards the projector head. Then push the motion picture condenser mount F over until the motion picture position stop F-4 hits the condenser stop screw A-4 on the lamphouse A, Figure 156.

HOW TO PUT THE ALTERNATING CURRENT REGULATOR ON THE BASE:

(Figure 152) Fasten the alternating current regulator D on the base C by means of the four screws C-6, found on the upper or rear part of the base, so that the control lever D-1 is on the side of the projector facing the projectionist. The four slots D-2 in the base of the regulator will line up with the holes C-7 in the base. Remove the terminal box cover D-3 and push the lamp leads A-5 and D-4 through hole D-5 marked "Lamp" in terminal box and fasten firmly to the two forward terminal screws D-6. The main line leads are attached in similar manner through hole D-7 marked "Line" to the two rear terminal screws D-8. Control lever

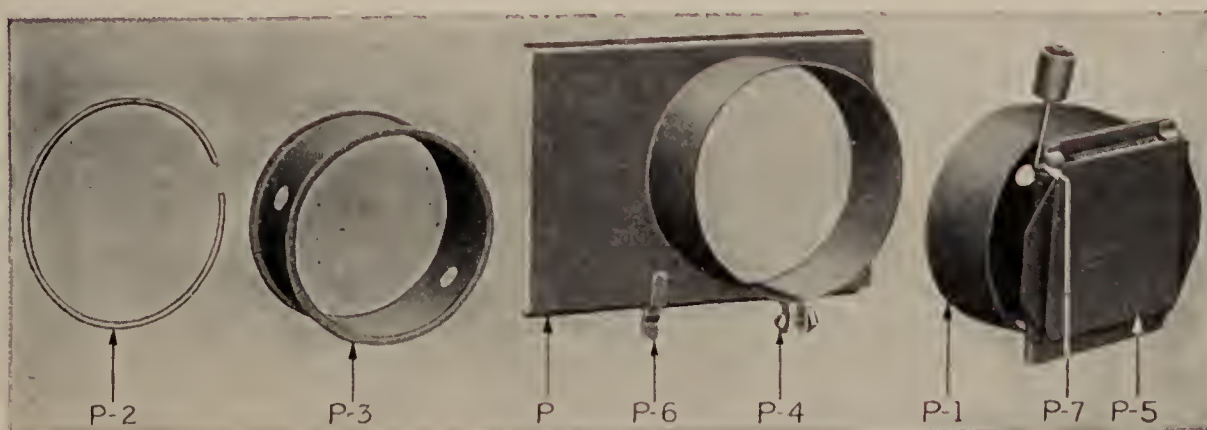


Fig. 154—Parts of Stereopticon Condenser Mount

D-1 should be in its "off" position before attaching main line leads. Then screw the terminal box cover D-3 in place. Be sure that the thin leather washer D-16 is in place on the switch stud before putting on the control lever D-1. Tighten the small screw D-17 fairly tight and then set the screw D-18 securely.

HOW TO SET AND ADJUST THE MAZDA LAMP IN THE LAMPHOUSE AND LAMP SETTER: Figures 155, 157, 158 and 164. Unscrew the large nickel head adjusting screw N-1 on the socket N until it is backed out approximately $\frac{3}{8}$ inch to $\frac{7}{16}$ inch. Loosen the small clamp screw N-2 until the upper half of the socket N-3 moves freely in all directions. Unscrew center socket contact N-4 until it is flush with the bottom of the socket.

Insert lamp R in socket N being sure to push the lamp all the way down so that it can move freely in all directions and not bind. Unscrew the two large knurled adjusting screws M-1 and M-2 on the lamp setter M and open the gate M-3.

Insert the lamp socket N with its lamp loosely in place in the lamp setter M and close lamp setter gate M-3. Turn the lamp in its socket until the edge of the filament is parallel with the notch in the gate M-4 and the notch in the frame M-5 opposite. Then by means of the focusing screw M-2 line up the filament with the notches mentioned above. (See Figure 155.)

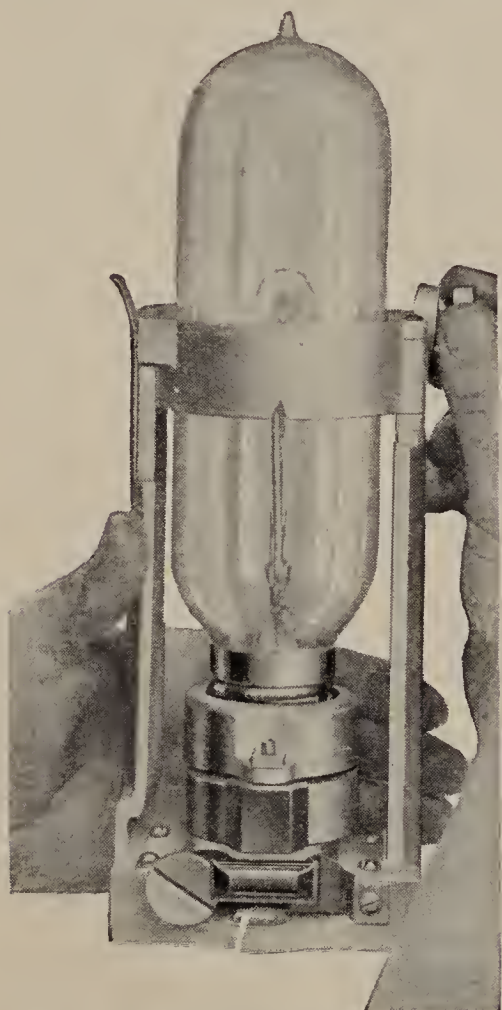


Fig. 155—How to Adjust Lamp in Lamp Setter

Sight through the two sighting holes M-6 and raise the lamp by screwing up the center contact N-4 from the bottom with the center contact key O until the bottom of the filament coils R-2 is flush with the lower edges of the sighting holes M-6.

Then as conditions demand, tighten or loosen the knurled lateral adjusting screw M-1 until the two line-up pins M-7 in the sighting holes M-6 come exactly between the two center coils of the filament. (See Figure 158.)

If the lamp filaments are not now vertical they may be made so by screwing or unscrewing the large nickel adjusting screw N-1 on the socket. Then the location of the filament with respect to the lining-up pins M-7 should be checked.

Then tighten or loosen the knurled focusing adjusting screw M-2 on the lamp setter until the filament is in line with the two notches M-4 and M-5, Figure 155.

Check the vertical adjustment (the position of the lamp filament) Figure 158 and the focusing adjustment (the location of the filament in the notches), Figure 155.

Tighten socket clamp ring N-5 by screwing up the clamping screws N-2 thereby locking the lamp in position in the socket.

Gently screw up bottom center socket contact N-4 against the lamp so as to insure good contact.

Open lamp setter gate and unscrew the knurled adjusting screws M-1 and M-2 until they do not touch the lamp. Check the lateral adjustment through the sighting holes M-6 and, if found to be slightly wrong, correct by screwing or unscrewing the large nickel adjusting screw N-1 on the socket N. This precaution is very important.

The socket with its lamp may now be taken out of the lamp setter with the assurance that the lamp will always be in correct position for projection, provided the lamphouse and motion picture condenser and socket base adjustments have been made.

Insert socket and lamp as far as it will go in the socket base S in the lamphouse A, Figures 162 and 165.

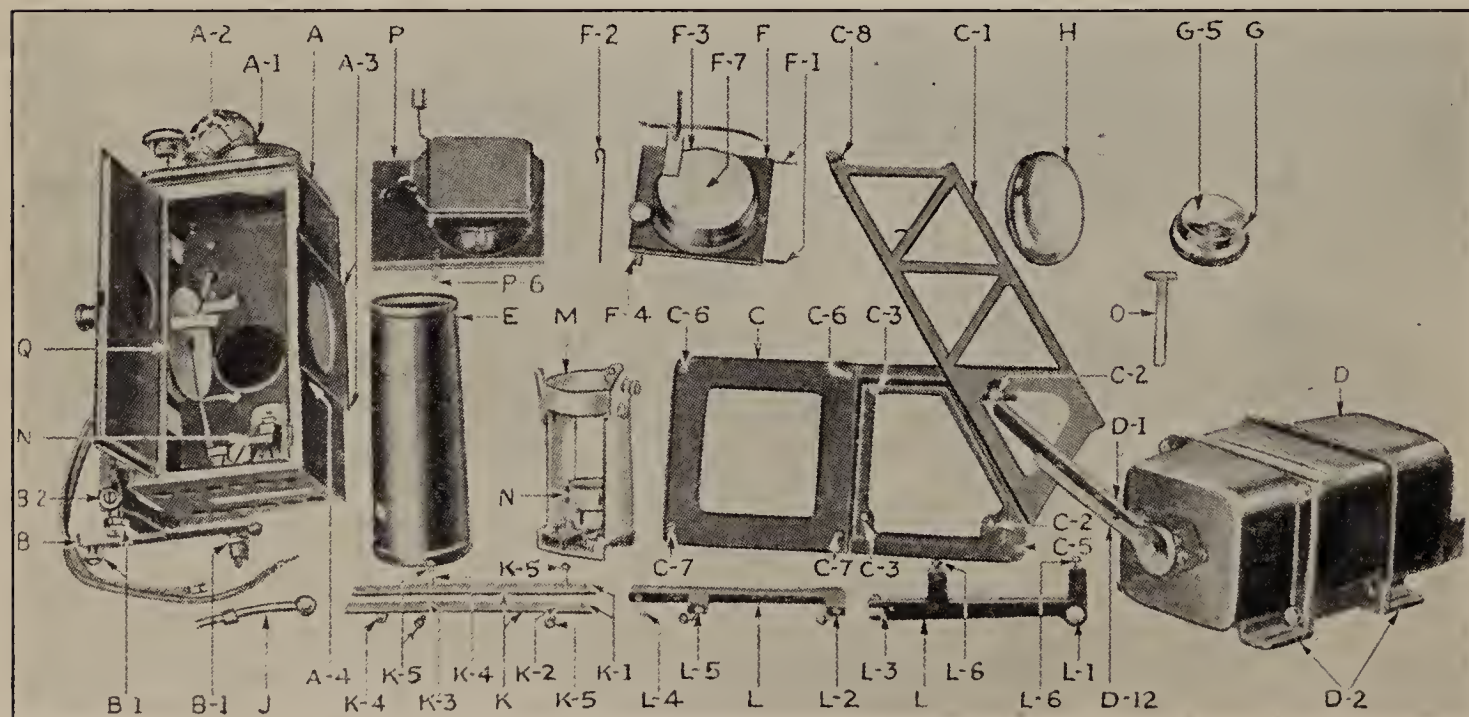


Fig. 156—Parts as Unpacked

Optical Alignment

In order to secure the maximum screen illumination possible the projecting lens, the aperture, the condensing lens and the lamp filament must be exactly on the optical axis of the optical train of the projector, because if any one of these elements has its center as little as 1/16-inch off this optical axis, the screen illumination will be greatly reduced.

Raise the automatic fire-shutter or open the gate of the projector. Pull the lamphouse A over until the carriage adjusting screw B-2 hits the carriage stop C-5 on the base C and push the motion picture condenser mount F over until its stop F-4 is against the stop screw A-4 on the lamphouse. (See Figure 165.) Move the base C forward or backward until the front surface of the bull's-eye of the prismatic condensers is 6½ inches from the edge of the aperture (except where state laws compel a greater distance) and fasten the base against further movement. Turn the flywheel until the revolving shutter of the projector has opened the projection lens.

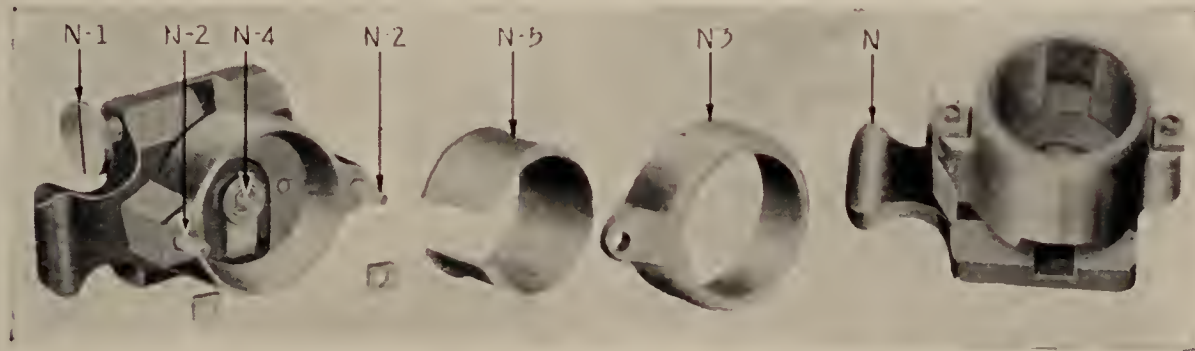


Fig. 157—Parts of Lamp Socket

The remaining adjustments must be made with the lamp lighted. (See Figure 163.)

Move the control lever D-1 of the Type HDS, Form E, alternating current regulator clockwise until the pin D-9 strikes the stop D-10. When the control lever D-1 is in this position the current passes through the warming reactance or choke coil D-11, which prevents a sudden rush of current to the lamp filament at the start and merely brings the filament to a glow.

Then push in the auxiliary lever D-12, thereby releasing pin D-9 and slowly move control lever D-1 clockwise until the ammeter needle G-5 registers 30 amperes. As the control lever D-1 is moved farther in a clockwise direction, more and more current is allowed to flow through the primary coil of the regulator and a correspondingly greater current through the lamp filament. Momentary drops in illumination as the contact fingers D-14 of the dial switch D-15 move from one contact to the next are prevented by the contact reactance D-13. To shut the current off, reverse the operation by turning the control lever D-1 counter-clockwise until it stops, thereby opening the circuit on the primary side of the regulator.

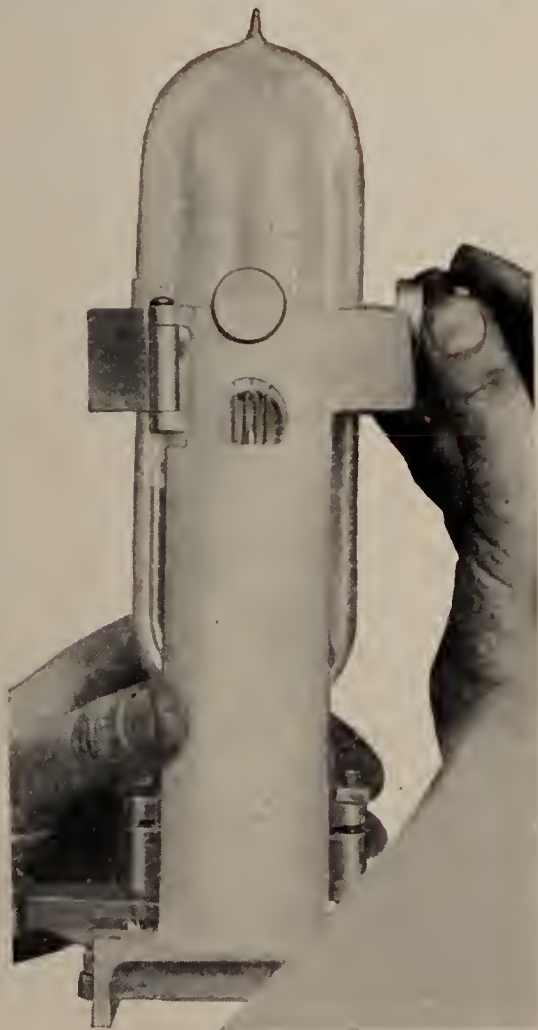


Fig. 158—How to Adjust in Lamp Setter

After the lamp is lighted, place a piece of dark-colored, low reflecting cardboard (usually the terminal box cover D-3 will prove satisfactory) and move it forward and backward in front of the projection lens, until the rings of the condenser are sharply focused on it. Loosen the four wing nuts A-6, Figure 152 on the back of the lamphouse and raise or lower the lamphouse until the same number of rings show up and down on the cardboard. After the image of the condenser is thus centered up and down, tighten the four wing nuts, A-6.

Next move the lamphouse to and fro on its carriage track until the same number of rings show on either side, or laterally, by screwing or unscrewing the carriage adjusting screw, B-2. Be sure



Fig. 159—How to Adjust Lamp in Socket Base

that when the prismatic condenser rings are centered, the motion picture position stop F-4 is shoved over against the condenser stop screw A-4, and that the carriage adjusting screw B-2 is against stop C-5, Figure 165. Set-screw B-3 should now be tightened. The prismatic condenser F-5 is now on the optical axis with the aperture and projection lens. Place the revolving shutter about $\frac{1}{2}$ -inch in front of the projection lens and turn the shutter until one of its blades intercepts the beam of light, Figure 159.

Tilt the reflector up by moving its focusing knob Q-1, Figure 165, down and locking knob Q-2. Place the image of the filament in the circle of light on the shutter blade. Figures 159 and 160. If the filament images are too far to the left, screw in the contact base adjusting screw S-1 and push the socket N farther into the lamphouse. If the images are too far to the right, unscrew the contact base adjusting screw S-1, thereby pulling the lamp out from the socket base S. The space between the two center coils of the filament should be in the center of the circle of light. (The filament image on the shutter may or may not necessarily be sharply defined and distinct.)

Loosen the socket base clamp S-2, Figure 165, and move the lamp forward and backward until the distance of the filament from the back face of the prismatic condenser is approximately $2\frac{1}{4}$ inches, and then tighten the socket base clamp S-2. Check the images on the shutter blade and, if correct, tighten the lock-nut S-2, Figure 162.

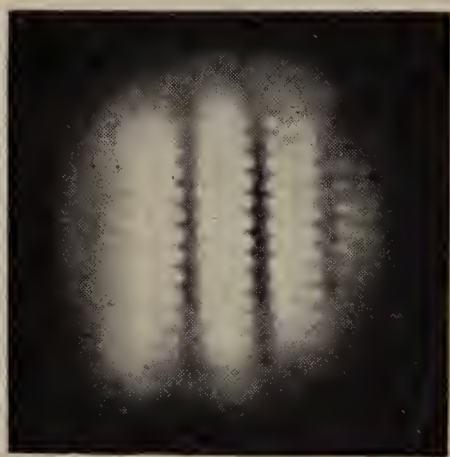


Fig. 160—Spot of Light
With Filament in
Center

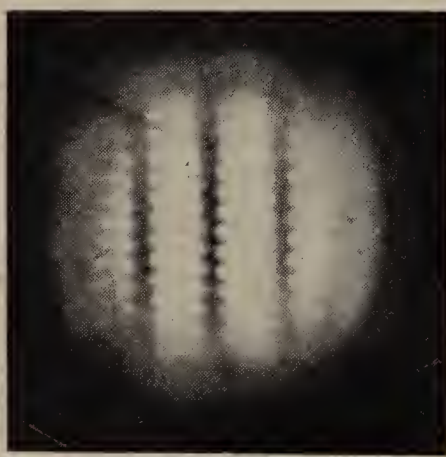


Fig. 161 A—Spot of Light
With Filament Off
Center

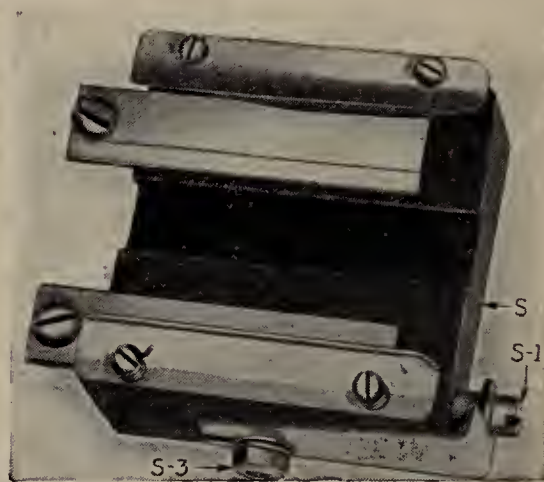


Fig. 162—Socket Base

The optical train is properly lined up if the prismatic condenser rings, as imaged on the cardboard, are perfectly centered both vertically (up and down) and laterally (sidewise), the filament image is in the center of the spot of light on the shutter blade, Figure 159, the spot of light on the cooling plate is small and centered, the lamphouse carriage B is against its stop C-5, Figure 165, and the motion picture condenser mount F is against its stop A-4, Figure 165. Then close the motion picture dowsers F-3 and the automatic fire-shutter. An image of the filament will be projected on the automatic fire-shutter, Figure 158, through the pin hole F-7. The fact that the image is off center with respect to the aperture does not indicate that the line-up is incorrect.

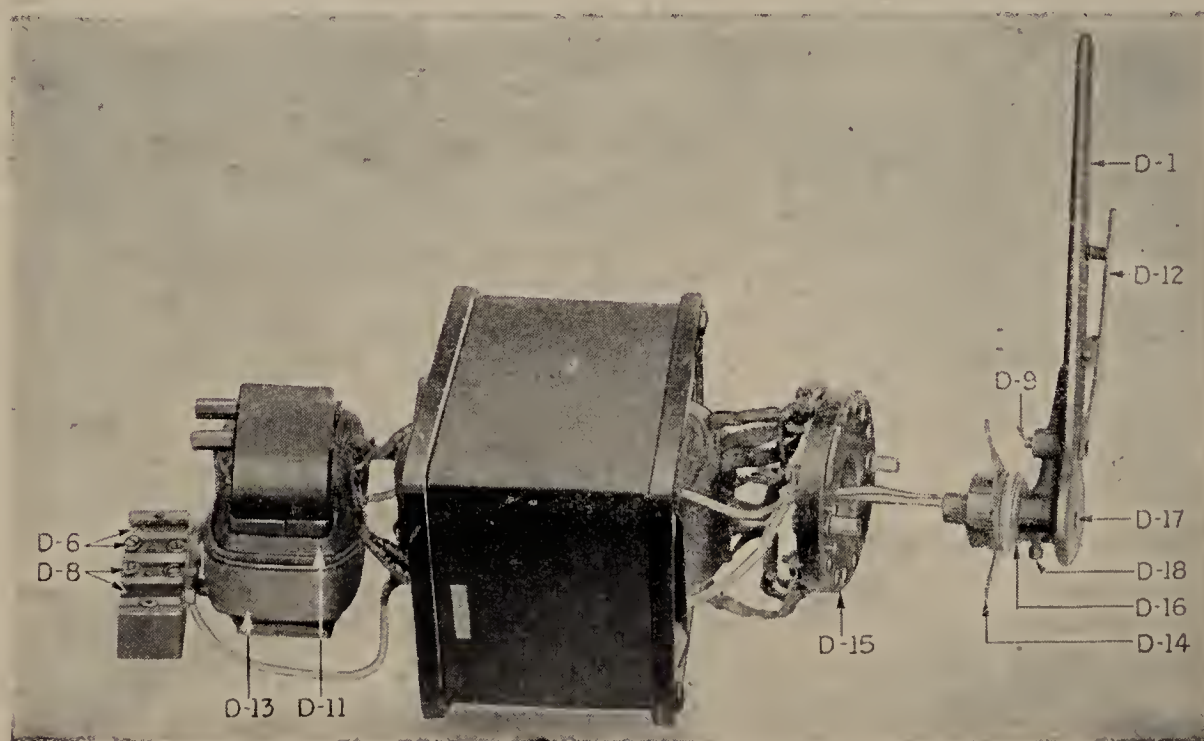


Fig. 163—Parts of Type II D S, Form E, A-C Regulator

Loosen locking knob G-2, Figure 165 and move the reflector H forward or backward by means of focusing knob Q-1 until the reflector image of the filament as projected on the fire shutter is exactly the same size as the filament image, Figure 128-B. Turning the focusing knob Q-1 clockwise will make the mirror image smaller; turning it counter-clockwise will make it larger.

After the reflector image is of the same size, move the focusing knob Q-1 to and fro, up and down until the mirror image of the coils meshes into the open spaces between the filament coils, thereby making a uniform source of light. Then clamp the mirror in position by tightening locking knob Q-2, Figure 165. If this lamp be now removed, and another lamp (correctly set up in the same lamp-setter) be inserted, the mirror image will mesh correctly as before (Figure 159); but if it does not fall exactly between the filament coils, move the reflector slightly one way or the other until the fault is remedied but do not touch the lamp socket or the adjusting screws N-1 or S-1.

Adjustments

HOW TO ADJUST FOR STEREOPTICON PROJECTION: (Figure 156) To adjust for stereopticon projection push the carriage B over on its track C-1 against the stop C-8. Then pull the motion picture condenser

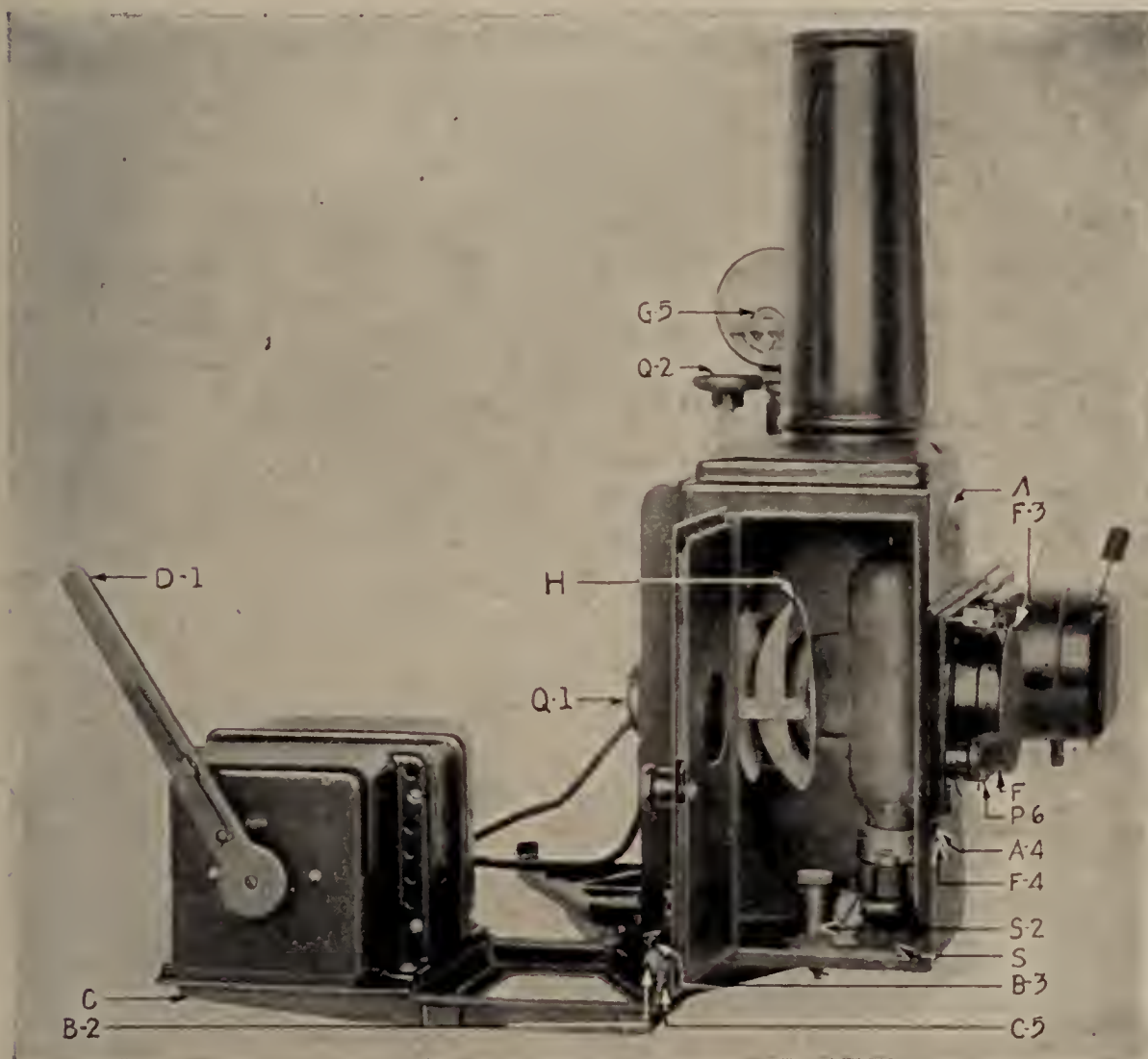


Fig. 165—Interior of Lamphouse With Lamp in Position

mount F over until the stereopticon stop P-6 hits condenser stop-screw A-4 on the lamphouse. Bend back the motion picture condenser mount F on its hinge F-1 against the lamphouse until the stop F-4 engages in latch A-7.

The setting of the lamp with respect to the plano-convex condensing lenses is done by moving the stereopticon condenser holder P-1 backward and forward until the field is clear instead of moving the lamp itself to and fro as is the case with the carbon arc. The distance for the lamphouse carriage B to be moved over may be controlled by loosening the set screw B-4 and by varying the distance of the stereopticon position-pin B-3 to the stop C-8, Figure 152.

Lamp Setting Devices

Figures 139 and 165 illustrate lamp setting devices for use with the two types of equipment described. With either of these appliances it is possible to adjust one or more spare lamps before a performance, each lamp in its own pre-setter, or jig so that in case a lamp burns out during the performance a spare lamp can be slipped into place in a few seconds.

The invention on which these pre-setting devices are based was originated by the Westinghouse Lamp Company and has been incorporated in both types of projection outfits.

The average life of a lamp is equivalent to a good many performances and usually the lamp is replaced, not due to its burning out but because the bulb has become unduly blackened or the filament sections have gradually sagged or warped out of shape to such an extent that replacement by a new lamp is desirable. Lamps frequently last longer than the rated life, but after they have been burning for 100 to 150 hours they should be examined to see that excessive light is not being lost due to blackening of the bulb or due to the fact that the filament sections are no longer parallel.

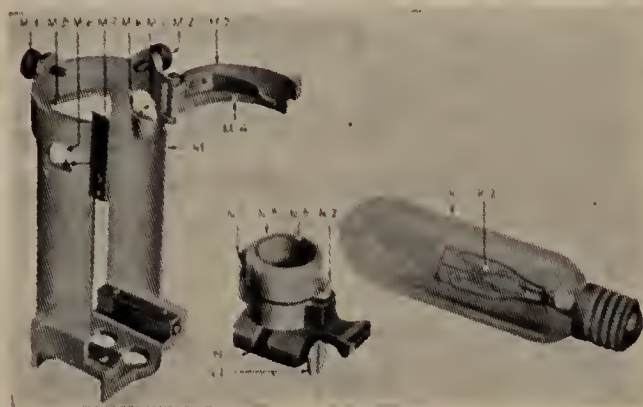


Fig. 164—Lamp, Lamp Setter and Socket

CONTROL APPARATUS

As the motion picture projection lamp must be operated at exactly the rated current, usually 30 amperes, it is necessary to have some device to hold the current at the correct value. Since the supply is usually 110 or 220 volts, it is also necessary in most cases to have a means of changing this voltage to the 30 volts required by the lamp. Usually one piece of apparatus serves both the above purposes.

Where alternating current is supplied, one of the following is used:

Automatic Current Regulator

Hand-Operated Current Regulator

Where direct current is supplied, any of the following apparatus may be used:

D. C. Rheostat

D. C. to D. C. Motor Generator Set

D. C. to A. C. Motor Generator Set

D. C. to A. C. Synchronous Converter with Transformer

Automatic Current Regulator for Alternating Current: As was explained in the section describing the motion picture lamp, it is essential that the current be held as nearly constant to its rated value as possible, since a slight drop in current decreases the amount of light tremendously and a slight rise shortens the lamp life to a marked degree. The automatic current regulator, as its name implies, is a self-acting device which compensates instantly for any line voltage fluctuations and delivers a steady flow of exactly the correct current to the lamp. This results in the projection being held at the most efficient point, and the lamp being given the longest possible life consistent with good pictures. This device acts also in the capacity of a transformer, efficiently stepping down the line voltage of 220 or 110 volts to the 30 volts required by the lamp.

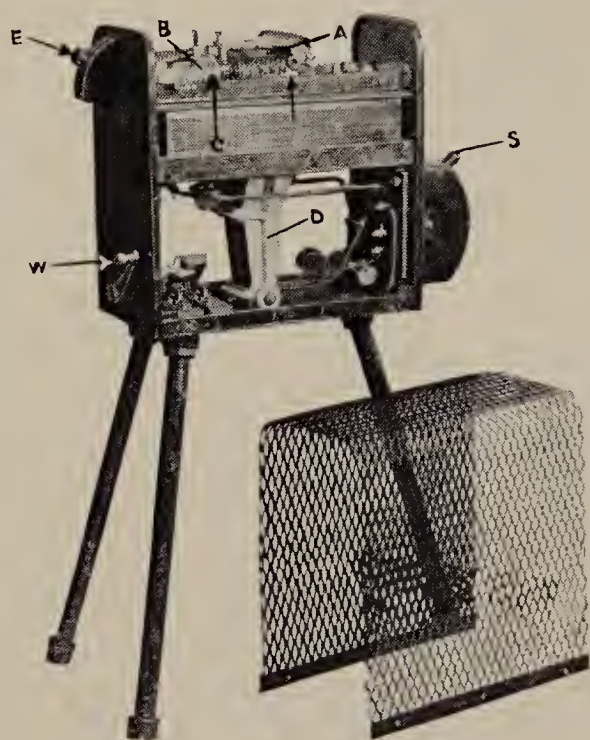


Fig. 166—Westinghouse Automatic Current Regulator



Fig. 167—Westinghouse Automatic Current Regulator

The Westinghouse Automatic Current Regulator, see Figure 166 and Figure 167, is the best known apparatus of the above type. It is based on the principle of the constant current transformer used so successfully in series street lighting.

The regulator is mounted on and is held rigid by three iron legs which are screwed into a cast iron supporting frame. This instrument is built with a stationary coil and a movable coil, the latter on a cast aluminum frame which is supported at the lower end by two sets of ball bearings allowing free movement.

This regulator is very sensitive and reliable. The principle on which it operates is one of magnetic repulsion. Current goes into the primary coil A, Figure 166, and sets up a magnetic flux which repels the secondary coil. Spring C, however, exerts a pull on the movable coil which swings upon the pivoted frame D so that the coil moves only to the point where the force of the magnetic flux is just counter-balanced by the pull of the spring. If the line voltage were held constant and the two coils held close together a large amount of current would flow through the lamp. If the two coils were held far apart a small current would flow through the lamp. The combined effect of the spring and the magnetic repulsion or "push" on the movable coil is such that the latter is always held at just the right distance from the fixed coil to cause the correct amount of current to flow through the lamp.

The importance of this automatic regulation of the current can be easily seen when the transformer is in operation, because the secondary coil is almost constantly moving to a new position to compensate for the fluctuations in the supply line voltage.

Referring to Figure 166, arm E is moved up or down over a calibrated scale until the lamp ammeter registers exactly the rated current, usually 30 amperes. This arm is then locked in place by turning the knob on its end, and the regulator will then continue to hold exactly this current without further attention.

Switch handle W controls the lamps. Moving it to the right causes lamp No. 1 to burn brightly and No. 2 lamp to glow at half current. Moving the lever to the left brings No. 2 lamp to full current and No. 1 to half or glow current. This glow current protects the lamp by admitting enough current to warm it up before full current is thrown on, thus avoiding the violent strain of throwing full current on a cold lamp. The half current is also a great convenience in adjusting the lamp and mirror.

The switch S, Figure 167, is used when the line voltage is below 90 or above 115 volts. For such an order of voltage, the regulator is still automatic, but on a different range. In practice, this switch, once set, is seldom changed.

Hand Regulator for Alternating Current: The transformer shown in Figure 74 is one of the most popular types of hand regulators for Mazda motion picture lamps. It is simple and compact, and efficiently steps down the line voltage to the 30 volts required by the lamp. It is usually mounted on the projector immediately behind the lamp house. See Figure 152.

This alternating current regulator is a straight transforming device with sufficient reactance to warm the lamp filament at starting. The contact points on the dial switch are connected to taps in the primary winding, so arranged that at no time in the adjustment of the switch is the current to the lamp interrupted.

The two end castings serve to clamp together a laminated core of the shell type with superimposed primary and secondary windings. A lever handle at the operating end is attached to an internal dial switch and

permits manual current-regulation within the operating limits of the lamp. To the other end is attached a connection box carrying the terminals for wiring to lamp and line. Slots are provided by which the regulator is attached to the base brackets directly behind the housing.

In starting the lamp, the lever is moved clockwise until the filament glows. At this point, a mechanical latch engages and the lever must be released before the lamp can be brought to full current. This slight delay is sufficient to protect the lamp from a destructive rush of current.

Since it is only in rare instances that direct current is supplied to a motion picture theatre, the discussion of control apparatus for this source of supply is of relatively minor importance. The following are briefly the considerations involved:

D. C. Rheostat: This is the simplest means of reducing the voltage from 110 to 30 volts. It also represents the lowest initial investment in control apparatus. However, the power lost is directly in proportion to the reduction in voltage so that the efficiency is only $30/110$ or approximately 27%. If a rheostat is used to cut down the voltage from 220 to 30, the efficiency would be only $30/220$ or 14%. In other words, 86% of the total power consumed would be wasted in the rheostat.

D. C. to D. C. Motor Generator Set: A set of this sort represents a higher initial investment but a much more efficient use of power. A 110 or 220 volt direct current motor drives a 30 volt generator and the only power lost is that required to overcome the relatively small mechanical and electrical losses in the machine itself.

D. C. to A. C. Motor Generator Set: The same financial situation applies here as in the D. C. to D. C. set. A direct current motor of 110 or 220 volts drives a 30 volt alternating current generator.

D. C. to A. C. Synchronous Converter with Transformer: In this case the functions of D. C. motor and A. C. generator are combined in one machine. The alternating current which is delivered, however, is not of the correct voltage for the lamp, and a transformer or regulator must be used to step it down to the 30 volts required.

The initial and operating costs of a combination of this sort are comparable to those of either of the two sets described above.

In general, when D. C. is used it will be found that a generator or converter set will pay for itself in a very short time, due to the saving in power which it effects as compared with the power wasted by a rheostat.

PROJECTION BOOTHS

Legal Requirements: In practically every location in the United States where motion pictures are shown, there are certain restrictions which the law imposes from the standpoint of safety. Since the law differs widely among the various states and municipalities, it is impossible here to go into details on this subject, but before the motion picture theatre is designed or built or before motion pictures are shown at any public gathering, the local building and electrical codes on the subject, as well as the National Electrical Code should always be consulted. Engineers of the Illumination Bureau of the Westinghouse Lamp Company will gladly aid the user in correctly interpreting these laws.

Practically every locality requires the use of a fireproof booth when a standard type motion picture film is shown. Some localities require a

booth even with standard size non-inflammable film, due to the ease of substituting inflammable or fast burning films in the machines without the knowledge of the authorities.

A distinction is usually made between the booth requirements for a motion picture theatre in which regular performances are given and the requirements for churches, clubs, schools and other places where the exhibition of motion pictures is more or less infrequent.

Comparison with Booth for Arc Lamp Projectors: Figure 169 illustrates good practice in booth construction for a moderate size theatre in which Mazda lamp projection is used. In the booth proper are shown

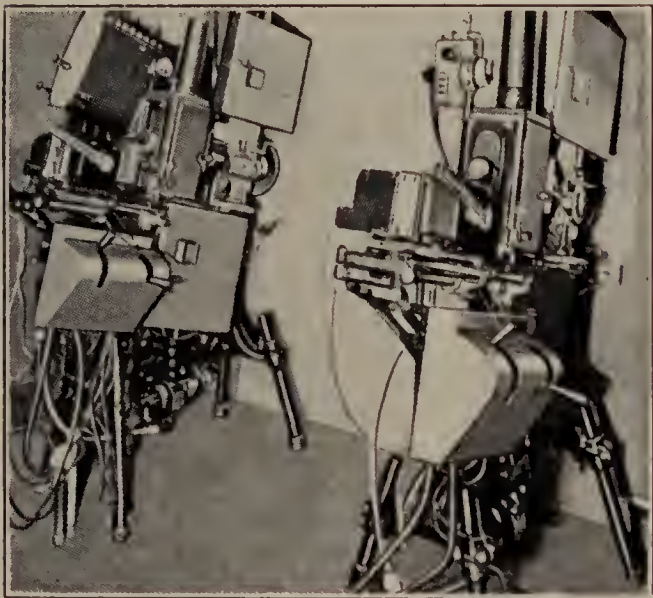


Fig. 168—Interior Views of Projection Rooms Equipped for Mazda Lamp Projection

two motion picture projectors and a stereopticon. With arc projectors, a motor generator is almost invariably provided as part of the equipment, and it becomes necessary to provide a separate fireproof room for the motor generator so that its noise is not heard in the booth and also because of the better safety features of such arrangement. One of the many advantages of Mazda lamp projection for small and moderate size theatres lies in the fact that such a motor generator is not needed on alternating current.

With the Mazda lamp equipment, which is free from the noise and vibration of a motor generator, it is a simple matter to place the booth just above the level of the seats in the rear of the first floor and so avoid the picture distortion which accompanies projection from a high position in the rear of the house.

The booths, properly incorporated as a part of the architectural plans

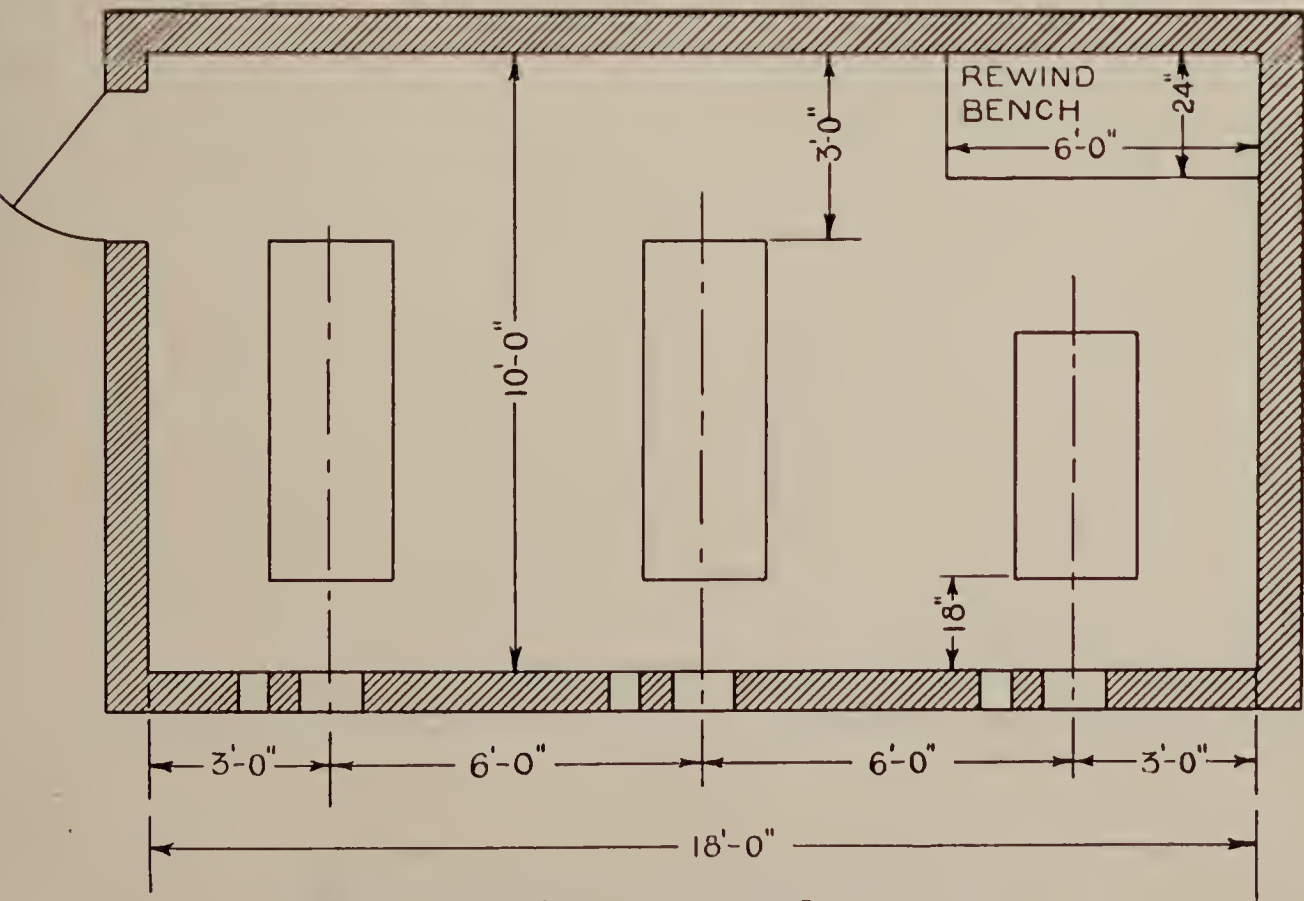


Fig. 169—Typical Good Projection Room Layout

of the theatre are made with tile or brick walls. Where the booth is installed after the theatre is constructed it should be of the particular material approved by the local authorities.

The law requires in almost all localities that all openings and ports in the wall of the motion picture booth be provided with safety shutters of fireproof construction, so arranged that in case of fire the shutters will automatically close and confine the fire to the booth. The shutters must also be mounted so that the operator can close them instantly in an emergency.

Usually there are requirements for proper ventilation of the motion picture booth. In the case of a Mazda lamp installation, the only ventilation necessary is that to provide fresh air for the operator. In the case of arc projection, however, the ventilation requirements are much more drastic, due to the soot thrown out by the arc lamps and to the serious fact that the arc itself vitiates the air, in fact poisons it by gradual additions of carbon monoxide gas that result in the incurable anaemic sickness of human beings. Most building codes require an opening of a certain size in the ceiling of the booth and a supply of fresh air at a given number of cubic feet per minute.

The following rules are typical of specifications issued by local law making bodies:

Condensed Rulings of National Electrical Code: IMPORTANT: These rulings are given here only to illustrate typical requirements. See complete rulings of National Electrical Code and local rulings before building or installing.

Machine Enclosure: Machines must be placed in an enclosure or house made of suitable fireproof material; must be properly lighted and large enough for operator to walk freely either side of or back of machine.

Ventilation for permanent booths must be provided by means of a vent pipe having a cross section of not less than 78 square inches; said pipe leading to the outside of the building or to a special non-combustible vent flue. All parts of vent pipe to be at least one inch from any combustible material or separated therefrom by means of approved non-combustible heat insulating material not less than one-half inch in thickness. A fan capable of exhausting fifty cubic feet of air per minute shall be installed and arranged in such a way that gas and smoke passing through the vent flue shall not come in contact with the motor. The motor must be connected to the emergency service and must not be controlled from the booth.

All openings into this booth must be arranged so as to be entirely closed by doors or shutters constructed of the same or equally good fire-resisting material as the booth itself. Doors or covers must be arranged so as to be held normally closed by spring hinges or equivalent devices.

Booth Illumination: A little thought given to the lighting of the booth will often improve its conveniences tremendously. In a great many cases the present booths are improperly lighted by a bare lamp hanging on a drop cord, often supplied with a makeshift sheet metal shade or a piece of cardboard in the attempt to partially screen the light. The most satisfactory ceiling luminaire for motion picture booths is an indirect or semi-indirect one, mounted in such a way that the light is not thrown on the motion picture screen, yet where the illumination is ample to see clearly the operation of all parts of the mechanism.

The location of the booth is of great importance in that a proper projection angle will eliminate one cause of picture distortion and will direct the greatest amount of light back toward the audience.

(See pages 42 to 44, inc.)

SCREENS

Importance: The screen is a very material factor in good motion picture projection. The size and shape of house and its purpose, whether used as a motion picture theatre exclusively, for motion picture and vaudeville, or for educational pictures; the location of seats and projection room; and type of projectors used, all have a very important bearing on size, surface, finish and location of the screen which will produce the most satisfactory results.

Screen Structure: The material of which the screen is made may consist of one of several different kinds of cloth, or rubber composition, or of a plaster or similar smooth wall. The cloths most commonly used are canvas, muslin, sateen and linen. Linen is rapidly going out of use for the purpose in question on account of its cost.

Untreated white cloth or white paint with a flat or non-glossy surface will give a reflected light distribution similar to the commercial diffusing screen, see Figure 170. Glossy cloth will show a distribution curve

intermediate between those of the diffusing and metallic screens. However, *the use of untreated cloth is most unsatisfactory* as such a screen is extremely inefficient, all the light which passes directly through the weave of the cloth being lost entirely.

Mounting: A good method of mounting the screen is to stretch it tightly on a strong wooden frame, such that there is no cracking or peeling of the screen due to bending, and any wrinkles which might appear can be removed by adjustment of the stretching devices.

Particularly in high school auditoriums, churches and other locations where performances are held infrequently, it is necessary that

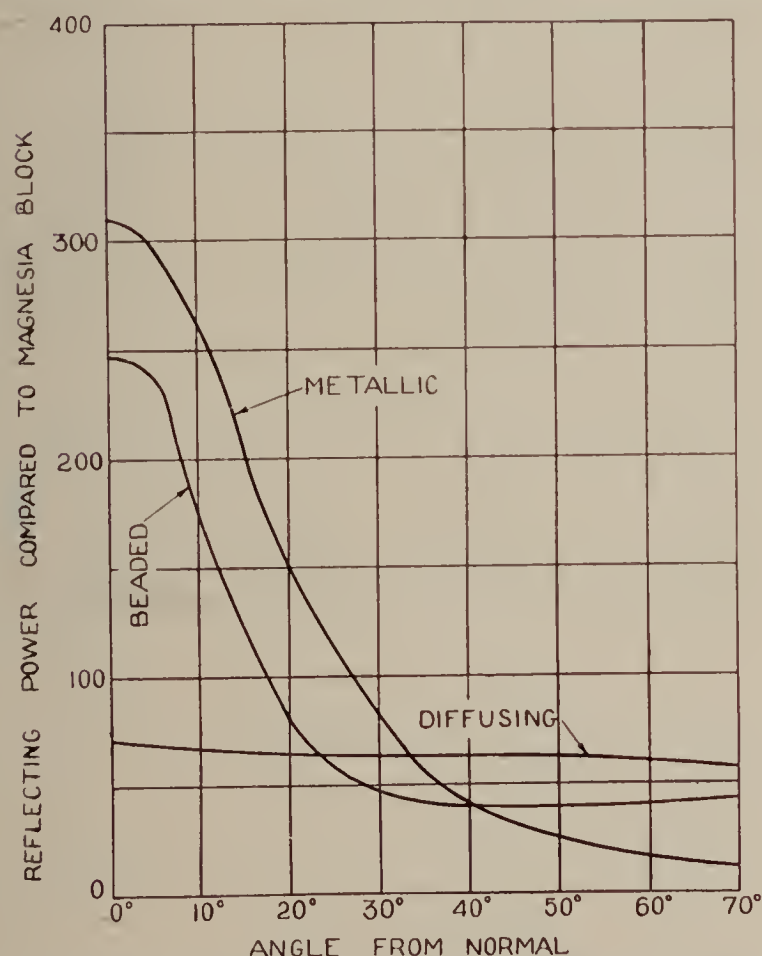


Fig. 170—Distribution of Reflected Light From Three Types of Motion Picture Screens

the screen be rolled up when not actually used for the projection of pictures, and this without any danger of cracking or peeling. Some very good screens are quite flexibly constructed. One method of accomplishing this result is to use on the cloth or other base a paint which is composed of a white pigment mixed with ordinary rubber cement or a liquid adhesive which has similar properties.

Frequently, the screen is painted directly on the wall of the theatre, the latter being of plaster or cement. If the plaster wall is properly treated with the same kind of material as is used in the construction of a high grade commercial screen, this method should produce a good picture background. However, frequently a mediocre paint is used, producing inferior results; furthermore, immobility is often a disadvantage. Where the screen is painted on plaster applied directly on the inner surface of one of the outer walls of the theatre, trouble is often encountered, due to the dampness of the walls. A fairly heavy rain on a brick wall or a sudden change of temperature will cause moisture to seep through or condense on the front surface of the screen, resulting in an extremely blotched and undesirable appearance. Such a difficulty can be overcome to a certain extent by waterproofing the brick wall, but the most satisfactory remedy is to install a commercial screen separately mounted a short distance from the wall.

Surfaces: Screens may be classified according to their surfaces, as diffusing, metallic or beaded, see Figure 171.

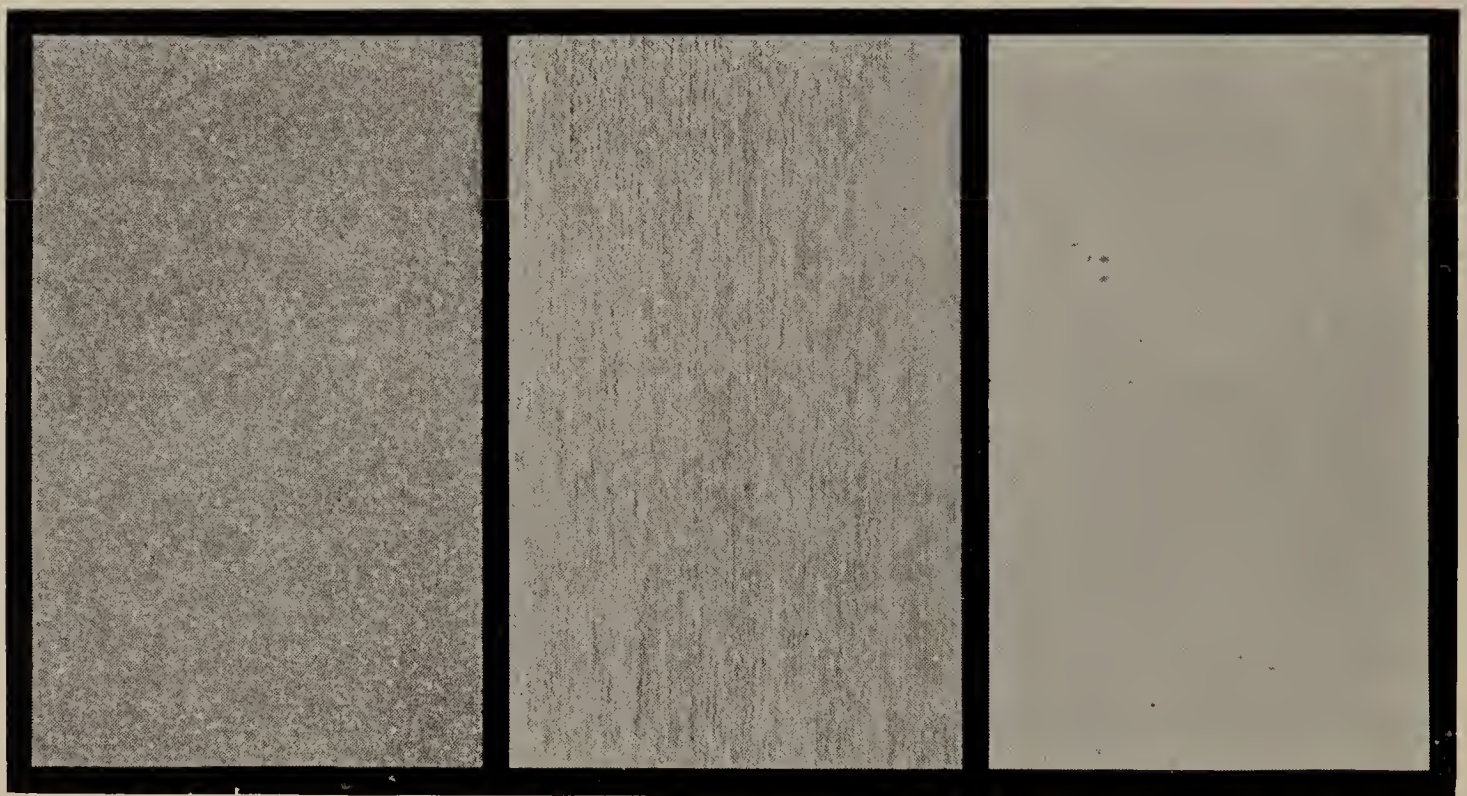


Fig. 171—Three Typical Motion Picture Screens. Left to Right, Beaded, Metallic and Diffusing

The difference in light reflecting properties of these three types of screens may be seen from the reflection curves of Figure 170. The diffusing screen, of which the flat matt plaster is the most common example, reflects the light to about the same extent in all directions. With this surface, at whatever angle the picture is viewed, the brightness is practically the same. The curve of the metallic screen, on the other hand, shows a very high value of reflected light directly in front of the screen which decreases rapidly as the spectator moves to the side. The beaded screen shows a curve more closely approximating that of the metallic. This screen is composed of a large number of minute glass beads mounted on a flat background, the beads forming innumerable small light reflecting surfaces.

In a number of cases a blue tint is added to an otherwise flat white screen in the attempt to give the picture an appearance more nearly pure

white. Except in cases where an extremely faint tint is used, this practice should be discouraged in motion picture projection unless the source of light is much stronger than is needed. While a noticeable tint of blue will give the effect of a white picture to a certain extent, it will appreciably cut down the efficiency of the screen, especially with the Mazda projection lamp. Moreover, the softer quality of the light from the Mazda lamp when not modified by a blue screen, is considered preferable.

Selection of Screen: The diffusing or flat white screen is superior to the metallic or beaded one for certain types of theatres only.

The diffusing screen is essential in an auditorium which is wide in proportion to its length. In this case the picture must be viewed at a considerable angle from the center and it is necessary for good results that the screen appear equally bright when viewed from any position. An example of such a condition will be seen in Figure 172.

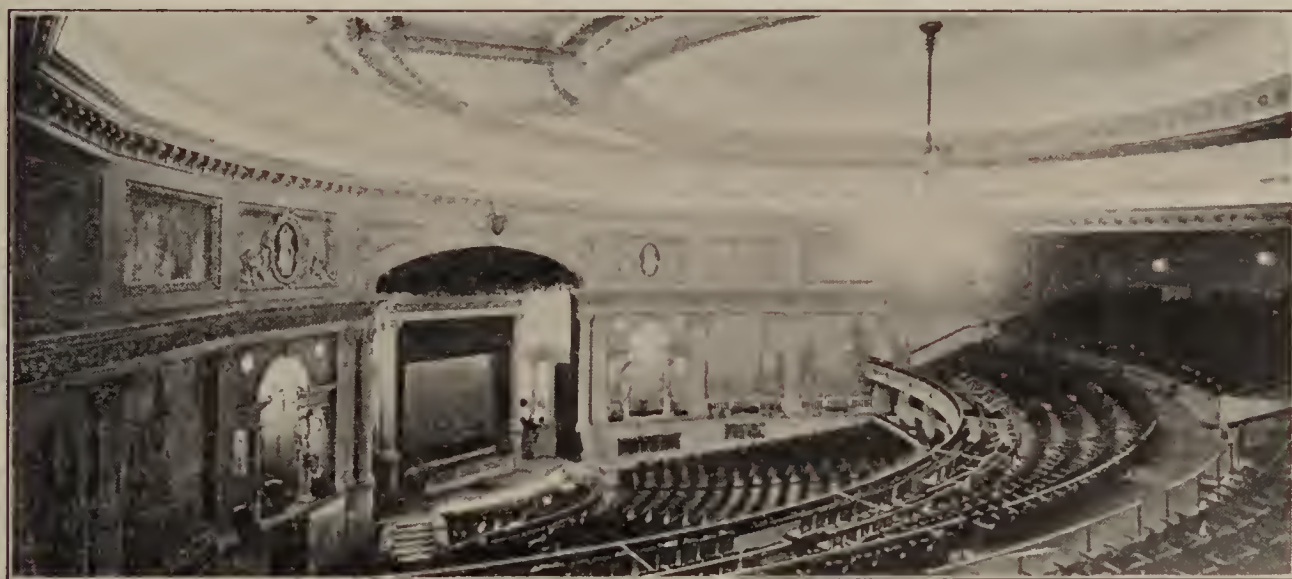


Fig. 172—Typical Wide Motion Picture House Requiring a Diffusing Screen

The metallic or the beaded screen is very desirable for a long and narrow house. The brightness of the screen, as viewed from directly in front or almost so, is much greater than in the case of the diffusing screen. The objection that brightness is very low when the picture is viewed at a considerable side angle naturally does not apply in this case. Such a situation is illustrated in Figure 173.

One striking manner in which the light from the beaded screen differs from that of the metallic screen is shown in Figures 174 and 175. When the projected light strikes the metallic screen at an angle, the resultant light is reflected somewhat downwards. In the case of the beaded screen, however, the light is reflected to the maximum extent back along the projected beam. Particularly in the case of a house having a high projection booth, care must be taken to see that a screen type and location are chosen which will produce satisfactory picture brightness for the entire theatre.

Location of Screen: When the diffusing screen is used, it appears to be of the same brightness no matter how high it may be placed on the stage. With a metallic or beaded screen, it will be seen from Figures 174 and 175 that the location has some effect on the distribution of light, and should be taken into account when designing the theatre.

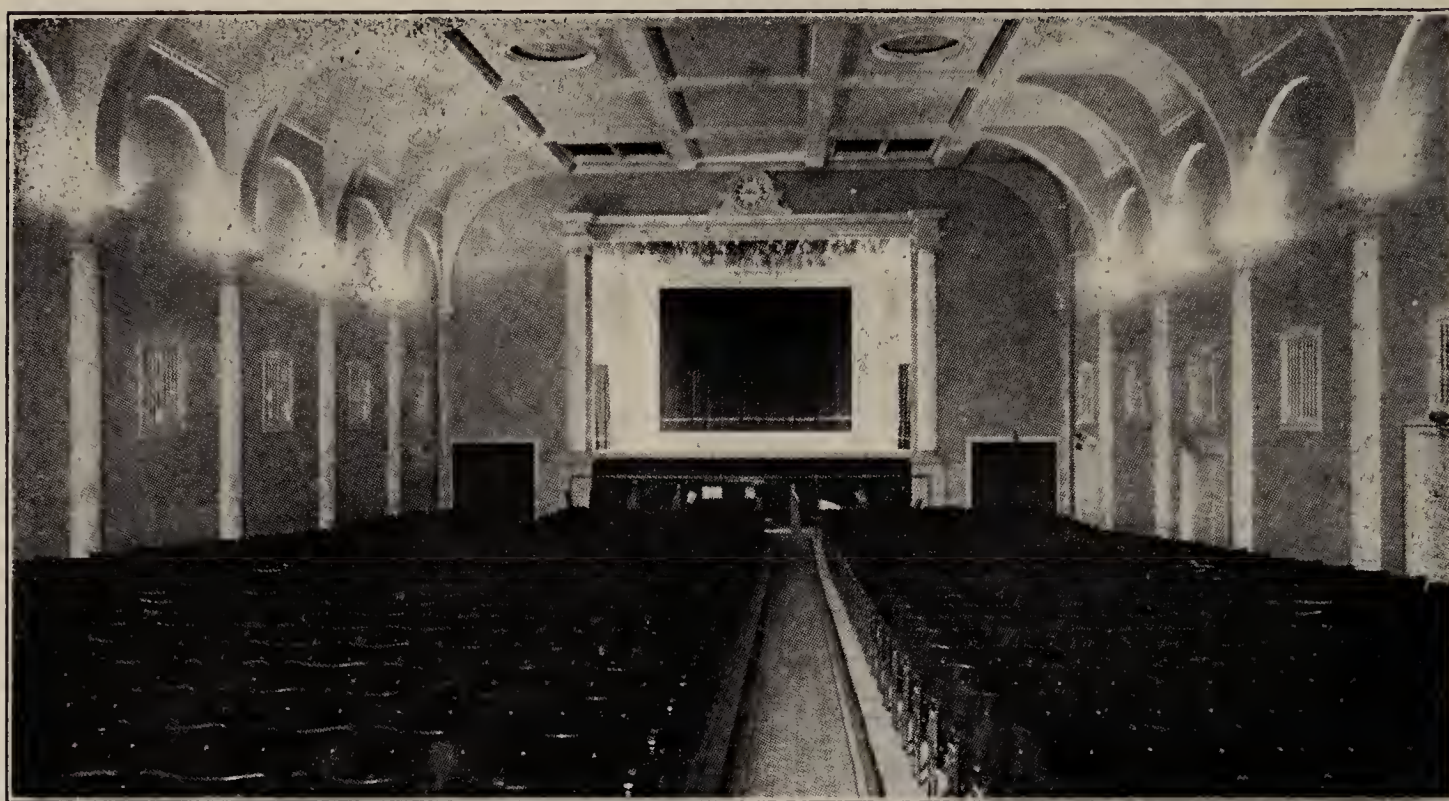
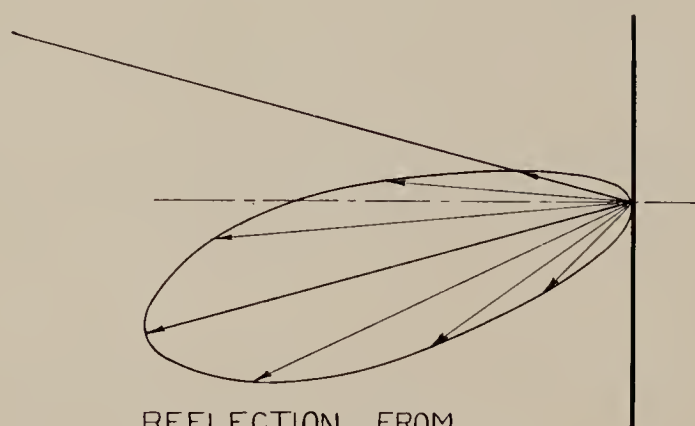


Fig. 173—Typical Long and Narrow Motion Picture House Requiring a Metallic or Beaded Screen

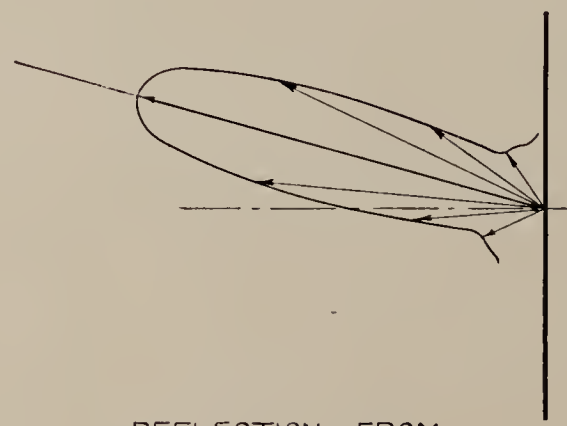
Brushing Screens: All types of screens should be brushed carefully at least once a month. Use a clean, soft counter brush and stroke the screen carefully, either straight across or up and down, brushing always in one direction only.

Washing and Resurfacing Flat White Screens: Practically all flat white screens, even those which do not have a surfacing of paint, can be washed without injury. Clean with a soft brush, castile soap and water every two to six months.



REFLECTION FROM
METALLIC SCREEN

174—Distribution of Reflected Light
From Metallic Screen



REFLECTION FROM
BEADED SCREEN

175—Distribution of Reflected
Light From Beaded Screen

Flat white screens which have a painted surface can more satisfactorily be resurfaced than washed. Every two to six months give the screen one or two coats of a flat white. Water color paint is preferable to oil paint.

Washing and Resurfacing Metallic Screens: The better grade metallic screens can be cleaned without injury. Rub dry castile soap over the surface and clean with a soft linen cloth. Common wall paper cleaner may be used if preferred.

Metallic screens will lose only a little in efficiency the first two or three cleanings, but repeated cleanings will reduce the efficiency more and more, hence do not use soap or wall cleaner on these screens more frequently than once in six months unless dirt conditions are unusually bad.

Most manufacturers of metallic screens will resurface them at a reasonable charge.

Washing Beaded Screens: The best quality beaded screen can be washed without injury. Do this every two to six months, depending on dirt conditions. Proceed as follows:

1st.—Construct a trough of wood or metal, which will rest along the bottom of screen, placed in position to catch the excess water. It is well to make provisions for draining this trough, preferably with a hose attached to it.

2nd.—Starting at the bottom and going from one side to the other, sprinkle the screen with cold water by the use of either a hose or sprinkling can, until the entire screen is thoroughly wet.

3rd.—Using an ordinary scrubbing brush, castile soap, and cold or lukewarm water, start from the bottom, working from one side to the other and thoroughly scrub the entire surface. Use plenty of soap and water and do not be afraid to scrub the screen hard, as any reasonable scrubbing will not injure it.

4th.—Rinse the screen well, starting from the bottom and working from side to side, using either a hose or sprinkling can. Now, but not until now, the screen should be allowed to dry thoroughly.

Always start at the bottom and work from left to right, right to left, etc., when wetting, scrubbing and rinsing, to obtain perfect results without showing streaks.

General Care of Screen: The useful life of the screen surface may be considerably increased by hanging a curtain directly in front of the screen, so arranged that it can be pulled to one side when pictures are being shown, but used as a covering at all other times. As a dust and dirt protection this is particularly good where screens are tilted instead of vertical as the former are more likely to collect a large amount of dirt.

When no such curtain is used, it is a good plan to direct one or two electric fans to keep dust and dirt from settling on the screen during clearing of the audience.

The useful life of the screen is so largely dependent upon local conditions, on the care taken and on the quality of the screen itself, that it is difficult to forecast. Screens usually last from one to five years. A life as short as one year is encountered only with an inferior quality screen, with a screen which is incapable of being washed, painted or resurfaced, or one mounted where an unusual amount of oily dirt will accumulate on its surface.

THEATRE ARRANGEMENT

Importance of Proper Arrangement: The form of the motion picture theatre interior is very important, both from the standpoint of artistic treatment and to obtain the maximum seating capacity. In considering the latter requirement, careful consideration should be given to the question of the proper arrangement to provide the maximum number of seats from which the audience may view the screen without undue distortion of the picture and without eye strain. A knowledge of the principles of motion picture projection, of the proper screen angle and arrangement of seats, is absolutely essential to the success of a motion picture theatre. The most important of these principles are outlined below.

Location of Projection Booth: The ideal location of the projection booth for a perfectly projected picture would be, of course, directly in front of the center of the screen. The customary compromise arrangement is to have the booth placed somewhat above the center of the screen but not off to either side.

If the projector is placed too far above the center of the screen so that the picture is thrown down at any considerable angle, the picture becomes distorted. In many cases where this is the situation, attempts have been made to overcome distorted appearance by filing the edges of the aperture plate to counteract the "keystone" effect on the screen. Done in the proper way, this can be made to produce a picture on the screen whose edges are parallel in truth, but the picture itself will be distorted in this case and no lens or combination of lenses can be made to compensate for the distortion of the objects in the picture.

If the projection booth is placed somewhat above the center of the screen, and for each 100 feet of projection distance, not more than 15 feet to one side, the condition shown in Figure 176 will apply.

In this case the angle C, known as the vertical projection angle, must not be greater than 15 degrees to avoid distortion. In other words, dimension D must not be more than one-quarter as large as dimension E. In rare instances it may be necessary to offset the projection booth to one side of the center of the screen by a greater amount than 15 feet for each 100 feet of projection distance. In such cases satisfactory projection may still be obtained, provided the angle C be reduced greatly. If the projection is nearly horizontal, the booth may be offset 20 to 25 feet to one side for each 100 feet of throw without unduly distorting the picture.

The motion picture screen is sometimes tilted so that the lower edge of the screen is nearer the audience than the upper edge, in the attempt to overcome distortion due to projection from a point very high in the house. This practice has a number of objections. It frequently produces eye strain due to the unnatural location of the plane of vision. Dust will accumulate much more rapidly on the tilted screen and its useful life will be very much shorter. In addition to this, it will be found that the tilted screen does not truly overcome picture distortion, except for one small portion of the audience.

Eye Strain: The most common cause of eye strain in poorly designed motion picture theatres lies in having the front seats so near the screen that it is necessary to look upwards at an angle too great to view the

picture comfortably. Such a prolonged unnatural visual position is always discomforting, since the direction of vision horizontally or slightly downward is natural and agreeable. Referring to Figure 176, it will be seen that the front seat is at such a short distance from the screen that it is

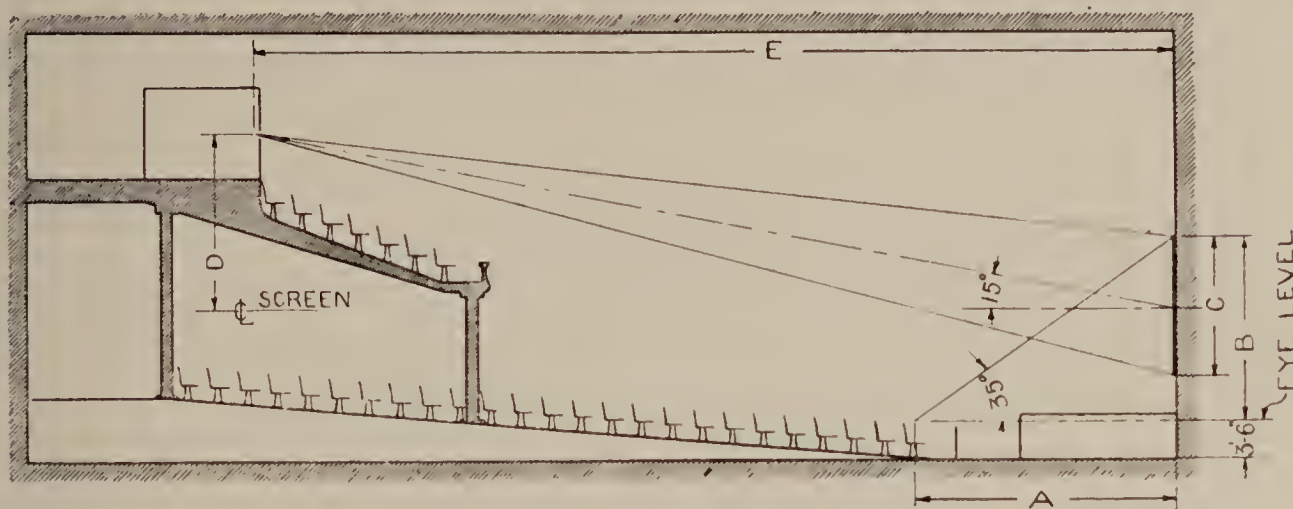


Fig. 176—Theatre Elevation Showing Locations at Which Picture Will Produce Eye Strain.
This Illustration Also Shows the Maximum Angle of Projection Room Above Screen
for Satisfactory Projection from the Standpoint of Picture Distortion

necessary for the occupant, whose eye will be about 3 feet 6 inches above the floor, to look upward at an angle of 35 degrees to see the upper edge of the picture. This has been agreed upon by authorities as the greatest angle at which pictures can be viewed in comfort. Dimension B is measured from the eye level to the top of the screen. Another way to express this limiting angle of 35 degrees is that dimension A must be at least 40% greater than dimension B. With the theatre arrangement shown in Figure 176 the front seat is as near the screen as good practice will allow, and the other seats in the theatre are all placed in such a manner that the picture can be viewed comfortably from any part of the house.

Eye strain may also be caused by viewing the picture from a position too far around to one side. However, this condition is very rarely encountered in actual theatre practice, since the picture is so distorted in appearance from any such position that the location of seats in these situations is out of the question.

Distorted Appearance of Picture: Referring again to Figure 176, the front seat of the theatre shown is passable from the standpoint of eye strain. It will be found, however, that when a picture is viewed from this position, even if the seat is directly in the center of the house, there will be distortion of the picture. With the theatre layout in question, probably three or four rows of seats will be sufficiently near the screen so that the picture will appear out of shape when viewed from them. This condition of affairs is indicated by the shaded position A, Figure 177.

In the theatre shown, the front row of seats is arranged in the arc of a circle, such that all the seats in the front are within the limiting position for viewing the picture without straining the eyes. Any seats which might be put in front of this row would be in a bad position from the standpoint of eye strain. This arrangement of seats is incidentally the most efficient one, providing the maximum number of satisfactory viewing positions.

The picture may also appear to be out of shape when viewed from too far to one side. If the horizontal angle of view, as shown in Figure 177, is not greater than 15 degrees, the picture will appear normal in shape, provided the seats are located a sufficient distance from the screen to be out of the shaded area, A. Between the angles of 15 degrees to 30 degrees measured from the axis of the house as is indicated in the above figure, the picture will appear to be moderately distorted. At angles greater than 30 degrees from the center line, the picture will be badly distorted. These angles apply, also, to the balcony seats.

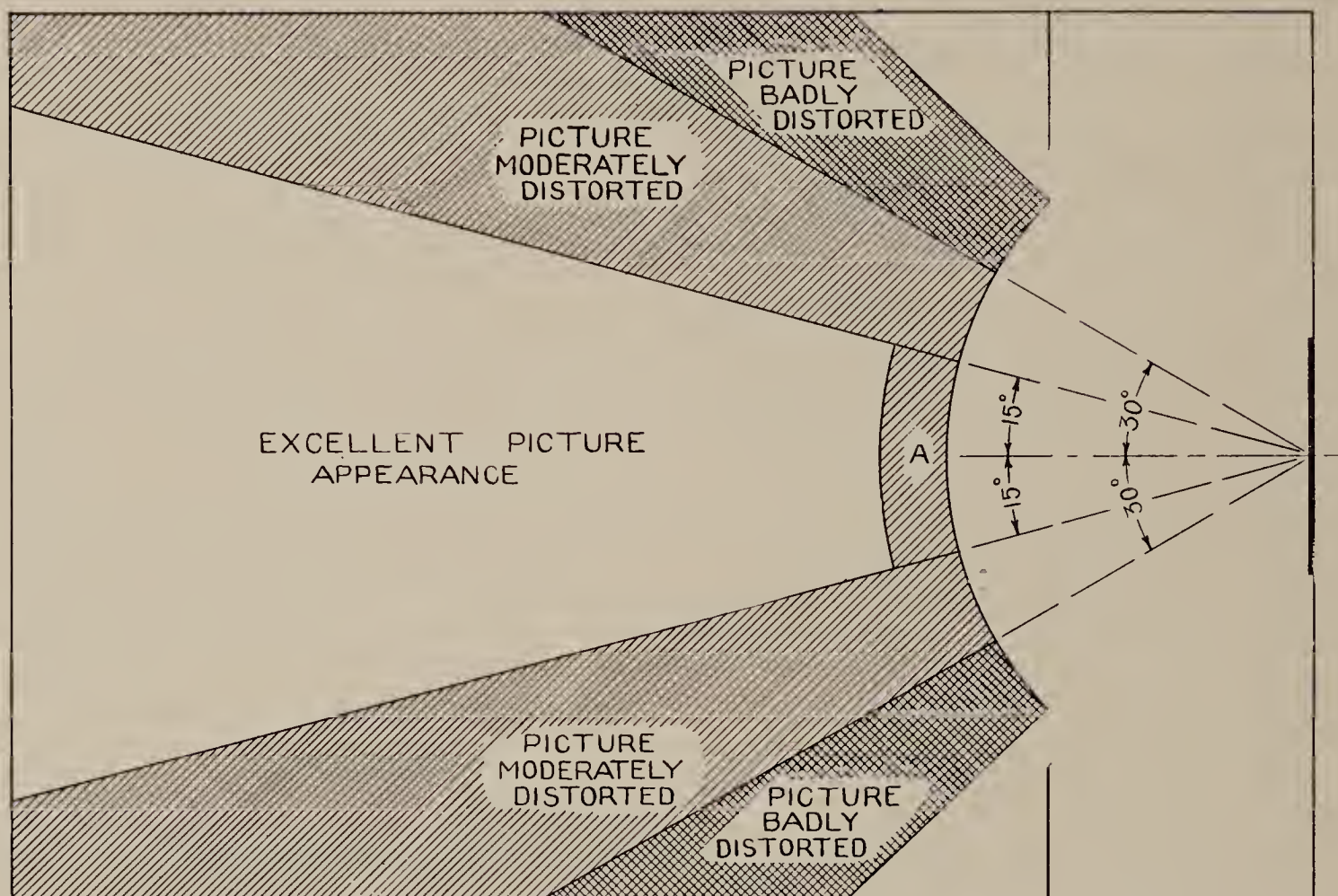


Fig. 177—Theatre Plan Showing Seat Locations From Which Picture Will Appear Distorted

In a theatre arranged as shown in Figure 177, there is no way of overcoming the unnatural appearance of the picture except to remove the seats in the bad area or to put the screen farther away. It can readily be seen that a larger proportion of satisfactory viewing positions can be obtained in a theatre if the top of the picture is not too high above the level of the front seats and if the screen is set back a considerable distance from the front row of seats.

If the theatre, whose plan is shown here, is to be used for vaudeville acts or for any other purpose where it is necessary to use a drop curtain near the front of the stage on which to throw the picture, it can easily be seen that the number of unsatisfactory seats in the house will be greatly increased. If a drop must be used in a case of this sort, it should be put back as far as possible from the front of the stage. In many cases it is possible to put the drop half way back stage until the last five or ten minutes of the picture. At this time another drop is lowered near the front of the stage while the remaining preparations for the act are made, the picture showing being uninterrupted.

THEATRE ILLUMINATION

Advantages of Theatre Illumination: There has been a noticeable tendency, in the last few years, among motion picture theatre architects and engineers to arrange for illuminating the interior while the performance is in progress.

There are a number of advantages to be found in this. It is much easier for people entering the theatre to find seats. There is much less strain to the eyes when a person comes into the theatre from a brightly lighted street, and the shock which is experienced in leaving the theatre and going into the brightly lighted street is much less marked.

There is much less strain on the eyes when the brightness of the screen is suddenly changed if there is a certain amount of general theatre illumination. Any flicker of the picture due to poor adjustment of the shutter is also less noticeable.

Probably one of the most important advantages to be gained from the house illumination lies in the fact that the eyes can properly adapt themselves to the brightness of the screen. With a pitch dark theatre and a bright screen, the eyes attempt to adapt themselves to the average conditions. The black surroundings, however, being of greater area than the screen have the determining effect and, as a consequence, the pupil of the eye opens to such an extent that the brightness of the screen is actually a source of glare.

A set of rigid rules for the illumination of theatres cannot be laid down, due to the variety of conditions that must be met. However, there are a number of individual problems which have to be solved, each one of which will be discussed here. When a problem of the illumination of a motion picture theatre arises, the service of an illuminating engineer should be combined with the service of the architect, so that the proper selection of lamps, equipment, color of walls and other factors may be made. This selection must be effected to bring about the best compromise to meet the conditions, both engineering and architectural, from the standpoint of art, unity, utility, safety and architectural requirements.

Wall Surface: Under this heading must be considered the question of whether the wall surfaces are to be glossy or matt. The colors of walls must be considered, as well as reflection factors. Glossy surfaces will seldom be desired from the architectural standpoint, while from the engineering standpoint they are extremely undesirable since it is difficult to so arrange the lights that the walls do not cause glare, due to the reflection of the bright light sources. Diffusing or matt wall surfaces should be used.

The brightness of walls and also of other objects in the field of view is a very important consideration, and in a motion picture theatre should not be greater than 3 millilamberts. Some conception of this value of brightness may be gained from the fact that an ordinary 25-watt Mazda B lamp, held 2 feet 8 inches from a white wall, will produce thereon approximately 3 millilamberts.

One of the most annoying glare sources from the point of view of the audience is the exposure of brightly lighted sheets of music used by the organist or other musicians. Whenever possible such sheets should be arranged so that they cannot be seen by the audience or else they should be illuminated by deep blue or other very subdued lights.

After choosing the wall color to be used, care should be taken to avoid such exposed luminaires as would themselves give brightnesses in excess of 3 millilamberts.

The reflection factor is a value which is very largely dependent upon the color. Low reflection factors may be obtained by the use of deep colors or by the addition of various quantities of gray to the original hue. In many cases the reflection factor must be low, near a luminaire to avoid a bright surface. Except in such locations, a brighter color for walls and ceilings is preferable, due to the cheerful appearance and also to the more efficient illumination produced.

Foot-Candle Values: In working out the illumination plan for the interior of the theatre, it is best to provide for a low illumination near the positions of the front seats, of approximately .05 foot-candle.

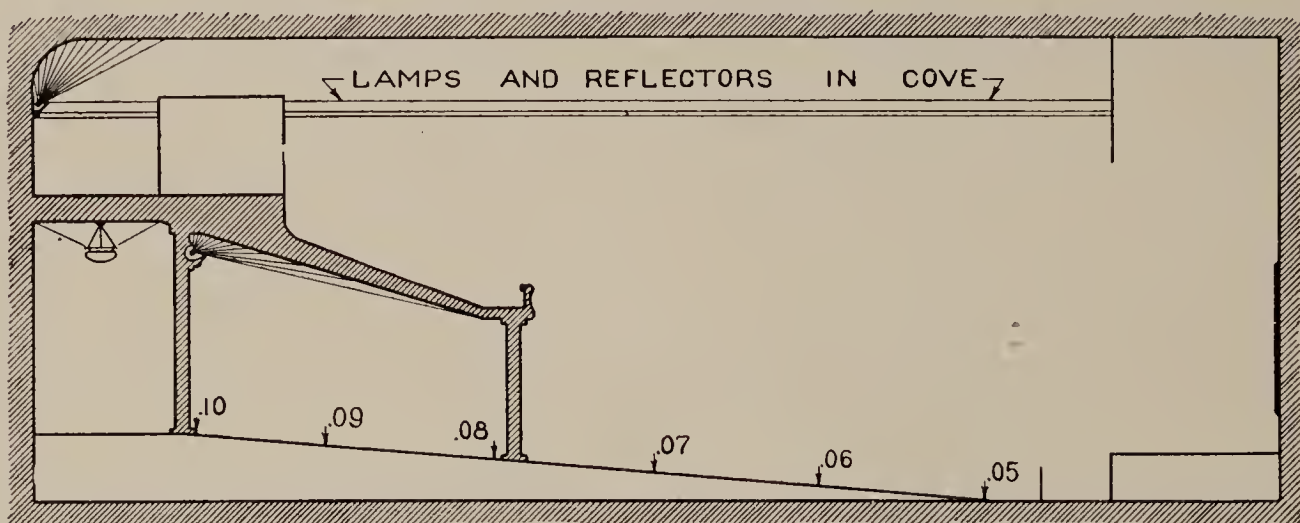


Fig. 178—Theatre Elevation Showing Method of Illumination. Concealed Lamps are Arranged to Show Colors as Desired. Numbers Along Auditorium Floor Indicate Foot-Candle Values Recommended During Projection of Picture

A unit foot-candle is the illumination produced upon a surface one foot distant from, and perpendicular to, the rays from a one candlepower light source. In order that this may be more easily understood, the illumination produced on a wall by an ordinary safety match held six inches from that surface would be approximately one foot-candle. Moonlight is on the order of one one-hundredth of a foot-candle. The illumination towards the rear of the theatre should be approximately 0.1 of a foot-candle when Mazda lamp projection is used. In between, the illumination should be uniformly graded. In the foyer a considerably higher value should be used, approximately 3 foot-candles. In the passageways leading to the street a still higher intensity should be used, about 5 to 10 foot-candles. With this arrangement a person coming in from a brightly lighted street can readily find his way, due to the fact that there is a gradual diminution which he experiences when passing to the dimly lighted seats in the front of the theatre. The change is so gradual that his eyes will accommodate themselves to the lower level of illumination by the time he reaches the front of the theatre. For the same reason when a person leaves a theatre there is no painful flood of light when he steps out to the street.

The Foot-Candle Meter: The Foot-Candle Meter, Figure 179, is a simple, compact and inexpensive instrument for the measurement of illumination intensities. It has a sufficient range to read the low values



Fig. 179—The Foot-Candle Meter for Measuring Values of Light Intensity.

of general illumination in motion picture theatre auditoriums as well as the intensity of light on the screen itself. The latter reading may be made from time to time with no film in the machine, to check the performance and adjustment of the projection equipment.

Typical Lighting Arrangement and Color Schemes: A good system of illumination is shown in Figure 178. Here the auditorium is lighted entirely by concealed light sources in the coves near the ceiling and under the balcony.

The lamps, in suitable reflectors, are spaced at close intervals along the coves, successive lamps being arranged to throw a flood of white, blue, amber, or red light on the ceiling, causing the entire auditorium to be filled with a soft glow of white or colored light.

The clear lamps should be arranged on two circuits with separate dimmers for each circuit, the first circuit being so arranged that when white light is used during the picture showing, the foot-candle values will be as indicated by the numbers in Figure 178. Both white light circuits thrown on together during the intermission should produce an intensity of 2 to 4 foot-candles throughout the auditorium.

All lamps of a certain color are grouped on a separate circuit with a dimmer, thus making possible a great variety of gradually changing color effects to suit the moods of the music and picture. Color is supplied by using properly coated lamps or clear lamps behind gelatine screens of different hues.

Additional striking effects may be obtained with color spot lights, and since all such color artistry adds so much to the pleasure of the audience, these effects should be carefully planned by experienced lighting experts.

PORTABLE PROJECTION OUTFITS

USES FOR PORTABLE PROJECTION OUTFITS

There is a rapidly growing demand for portable outfits for projection of motion pictures to serve a number of interesting purposes, among which are the following:

General Educational Work: Both standard and portable types of projectors are suitable for use in educational work. The importance of this particular field of endeavor is so great that the subject is given an entirely separate division of this bulletin.

Church Entertainments: There are several ways in which motion pictures have made a welcome for themselves in church work. Both the standard and portable machines are suitable for this use, although



Fig. 180—Portable Motion Picture Projector in Schoolroom

the latter are much in the majority. There are a number of very good religious films on the market which portray various incidents in ecclesiastical and biblical history. Other films of an educational nature and good photoplays are frequently employed as a means of clean social entertainment, and are also frequently used as a means of raising money for the church; some churches even having regular motion picture performances at stated days of the week in rooms which can be readily fitted up for the purpose.

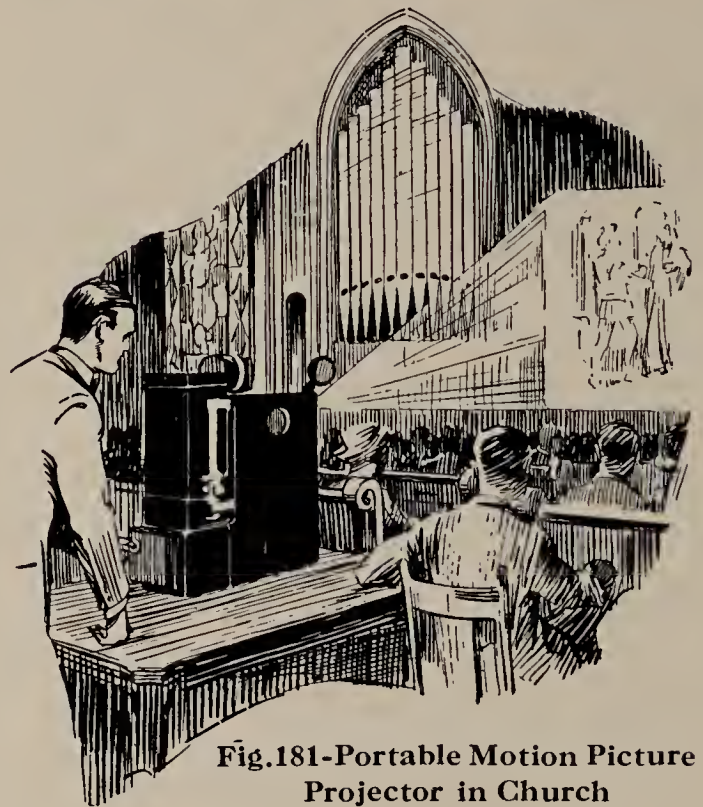


Fig. 181—Portable Motion Picture Projector in Church



Fig. 182—Portable Motion Picture Projector Used in Business Demonstration

Motion Pictures in the Home: The smaller types of motion picture projectors, practically all of which are portable, have in recent years gained a tremendous popularity for use in homes. Such a projector used in conjunction with one of the more popular types of small motion picture cameras adds the element of motion to the possibilities of the stationary photograph. The costs of initial equipment and of taking the pictures have been brought to the point where they can be afforded by a great many people, and the fas-

cination of this form of amusement has shown itself in a striking manner.

Motion pictures of this sort can be taken of the family and domestic scenes, incidents of interest in travel or on hunting trips, and at big games and races.



Fig. 183—Portable Motion Picture Projector in Home

In addition to the possibilities of showing moving pictures which have been taken by the amateur himself, the home motion picture outfit makes it possible to show a great variety of photoplays, educational films and comic films. Certain well known companies have large, thoroughly equipped film libraries, from which films can be rented in much the same manner as books are taken from a circulating library.

Welfare Work: The benefit of instructing in welfare work with the aid of the motion picture is gaining widespread recognition. There is no difficulty due to difference in language in getting the messages across, as the motion picture represents the universal language. Instruction given through the aid of motion pictures is understood much better and remembered many times longer than instructions with still pictures and oral explanation, or instruction without pictures.



Fig. 184—Portable Motion Picture Projector

Motion Pictures in Business: There are tremendous possibilities for the use of motion pictures in business, particularly from the sales standpoint. A number of large corporations in this country have provided members of their sales force with motion picture projectors. These salesmen are able to take to their prospects the picture

story of the product they have to sell. In a sense, they may be said to take their factories, machinery, or bulky merchandise directly to the prospect's office and show them to him under actual working conditions. The sales power behind such a demonstration is a force of the greatest importance.

LAMPS

Types: The types of Mazda lamps which are commonly used and which are recommended for portable motion picture projectors are shown below.

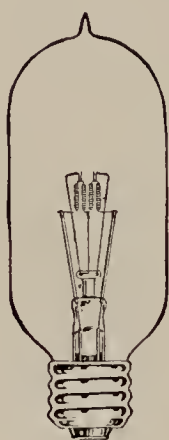


Fig. 185
30 Volts
300 Watts

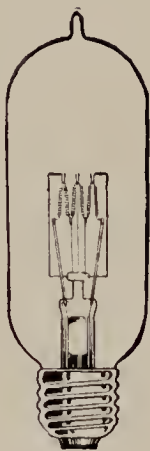


Fig. 186
110-115-120 Volts
250 Watts

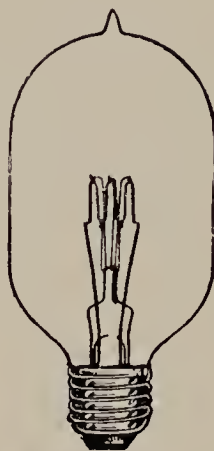


Fig. 187
110-115-120 Volts
400 Watts

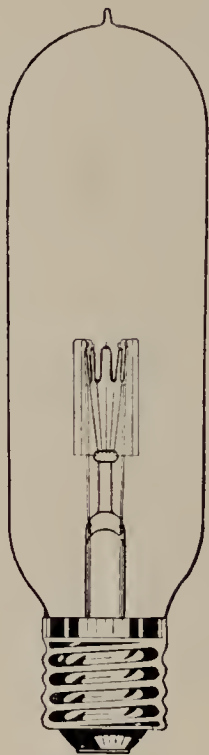


Fig. 188
110-115-120 Volts
1000 Watts

MAZDA C LAMPS—PROJECTION—TUBULAR BULBS
28-32 VOLTS

AMPS.	WATTS	HOURS LIFE	BULB	DIAM. OF BULB	SCREW BASE	OVERALL LENGTH INCHES	LIGHT—CENTER POSITION*	POSITION OF BURNING	PACKAGE QUANTITY	LIST PRICE
..	300	100	T-16	2"	Medium	5 5/8"	3"	Tip-up	12	\$2.75
20	600	100	T-20	2 1/2"	Mogul	9 1/2"	4 3/4"	Tip-up	6	6.00
30	900	100	T-20	2 1/2"	Mogul	9 1/2"	4 3/4"	Tip-up	6	6.75

MAZDA C LAMPS—PROJECTION—TUBULAR BULBS
110, 115 AND 120 VOLTS

..	250	100	T-14	1 3/4"	Medium	5 5/8"	3"	Tip-up	24	\$1.75
..	400	100	T-20	2 1/2"	Medium	5 5/8"	3"	Tip-up	6	3.00
..	1000	100	T-20	2 1/2"	Mogul	9 1/2"	4 3/4"	Tip-up	6	7.00

*The distance in inches from base contact of lamp to center of filament.

Uses: The 900 watt 30 ampere and 600 watt 20 ampere Westinghouse Mazda lamps, previously illustrated, may be used wherever a suitable means is at hand for providing the proper voltage and current. Usually, however, this is not found available outside of regular theatres, and so they are not usually used in portable projectors.

The 300 watt, 28 to 32 volt lamp illustrated above, is built for use where the voltage of the range mentioned is available, chiefly with isolated or farm lighting plants. If the voltage is slightly above 32 or is apt to vary somewhat, it is perfectly feasible to supply a suitable rheostat for current control due to the low current which is consumed by this lamp. In the case of the 900 watt 30 ampere, and 600 watt 20 ampere lamps, the rheostat would be difficult to build in portable form and very wasteful, due to the large current to be controlled.

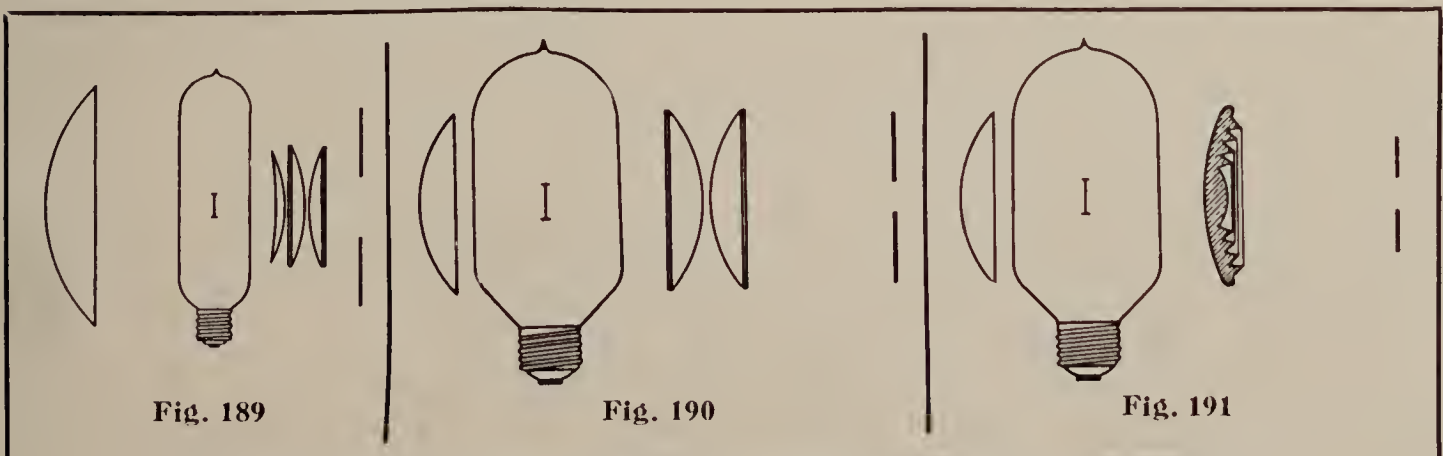
The 250, 400 and 1000 watt projector lamps for 110, 115 and 120 volt service can be connected directly across the usual lighting line. This makes them extremely desirable for portable outfits and it is largely for this reason that they are used to a much greater extent than the other projection lamps mentioned.

Lamp Construction: All of these projection lamps operate with the filament at a very high temperature, with filament wound in as concentrated a form as possible. A special glass is used for the bulbs to enable them to withstand the high temperature. Like the 900 and 600 watt lamps mentioned above, the bulbs are tubular in shape, thus minimizing trouble due to blackening of the bulb and making it possible to place the lamp closer to the lens.

As is the case with the 900 watt 30 ampere and 600 watt 20 ampere projection lamps, the same engineering organization of the Westinghouse Lamp Company has gone thoroughly into the question of the most satisfactory design and construction of these lamps. This has been followed up with the most thorough and rigorous practical tests under actual operating conditions to insure satisfactory service in the field. The manufacturer stands behind the lamp after it is sold to the consumer, and is glad to give any advice or render any service possible to assure to the customer the best results.

OPTICAL SYSTEM

Optical Principles: The same principles of optical projection apply in portable projection machines as in the large standard type projectors. Practically the only difference is in the sizes and focal lengths of the lenses and mirrors and in the size of the other parts of the projector. The plano-convex, corrugated and meniscus plano-convex lens systems are all used in portable projectors.



Three Types of Portable Motion Picture Projection Condenser Systems

The optical systems shown in Figures 189, 190 and 191 are those of three popular types of portable motion picture projectors. It will be seen that the corrugated and plano-convex lenses are only 3 inches in diameter as compared with the $4\frac{1}{2}$ -inch diameter lenses used on standard machines, and the meniscus plano-convex is only about 1 inch in diameter, nevertheless a considerable amount of light is intercepted and used by all these lenses since with the tubular bulb lamps the filament can be brought very close to the lens. The mirror should always be used as in the case of the large projector.

Objective Lenses: The most common sizes of objectives used in portable projectors are those known as $\frac{1}{8}$ size or No. 0, somewhat smaller in diameter than the $\frac{1}{4}$ or No. 1 size, previously described. They can be obtained in focal lengths ranging from $2\frac{1}{2}$ to 6 inches, in $\frac{1}{4}$ -inch steps.

In many cases it is possible to use a $\frac{1}{4}$ size lens in a portable projector. Where the manufacturer finds this possible he should make arrangements so that the $\frac{1}{4}$ size lens may be used interchangeably with the $\frac{1}{8}$ size. These larger diameter lenses throw more light on the screen in the same way as in the case of the standard projector, *i.e.*, the $\frac{1}{4}$ size lens projects more light than the $\frac{1}{8}$ size.

Method of Adjusting Lamp in Optical System: Due to the difference in construction between the portable and the standard projector, the same method of adjustment cannot be followed throughout. The recommended method of adjusting the lamp and optical parts of the portable projector is as follows:

(a) Adjust the plane of lamp filament parallel to the aperture.

(b) Set the lamp so that the filament is the desired distance from the condenser. In some cases the manufacturer specifies this distance. In other cases the position of the lamp socket is fixed so that it cannot be moved forward or back.

(c) Throw the mirror entirely out of adjustment, or if this is impossible, place a sheet of cardboard or asbestos temporarily between the lamp and mirror. If the cardboard is used, be sure there is no film in the machine as the heat of the lamp may set fire to the cardboard. Hold a sheet of paper or cardboard in front of the machine and move it back and forth until the images of the lamp filament are focused as sharply as possible on the paper. The effect should be similar to that illustrated in Figure 160, page 30.

(d) If the lamp is not properly adjusted sideways the images of the filament sections will not appear in the center of the round spot of light, as shown in Figure 161, page 30. Move the lamp laterally until the filament images are centered. For proper vertical adjustment, move the lamp up until the lower part of the spot becomes dark, then down until the upper part of the spot becomes dark, and then secure the lamp half way between these two positions.

(e) Remove the cardboard or asbestos from between the lamp and mirror and adjust the mirror so that the filament images which it throws on the paper in front of the projector will fall directly between the primary images mentioned above.

The complete outfit has now been properly adjusted and it should be possible with this setting to throw a uniform white field of light on the screen.

PROJECTORS

Types of Projectors: There are a number of different types of portable motion picture projectors on the market. Four representative ones are shown in Figures 192-195, inc. These, and most of the others on the market are either built in so-called "suitcase form" so that they have the general appearance of a suitcase, or they can be carried in special traveling cases which are supplied with the machines. Figure 194 illustrates a portable projector which can be used for stereopticon slides as well as motion pictures. The illustration shows the lamp house in the lowered position for showing motion pictures.

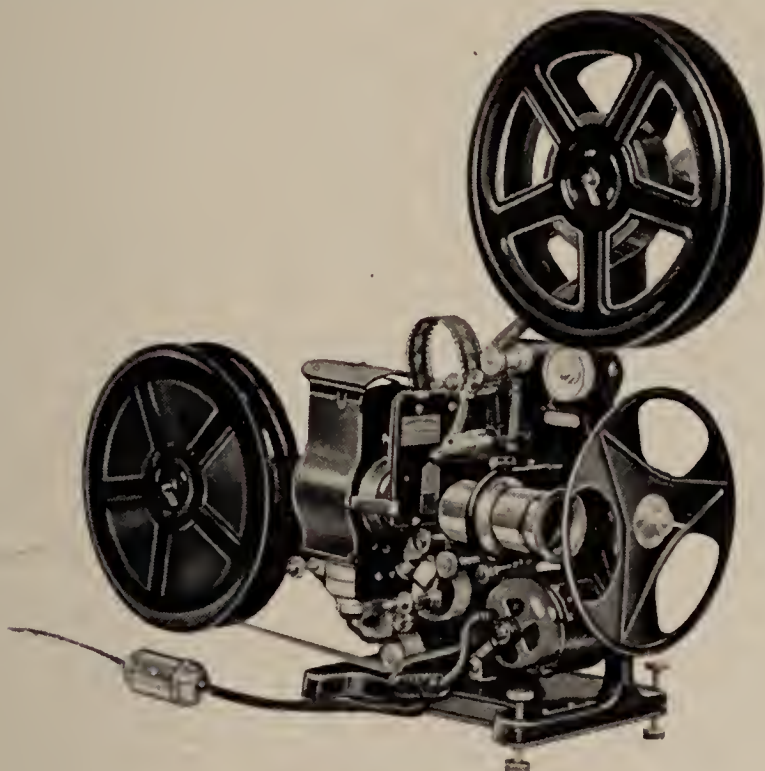


Fig. 192

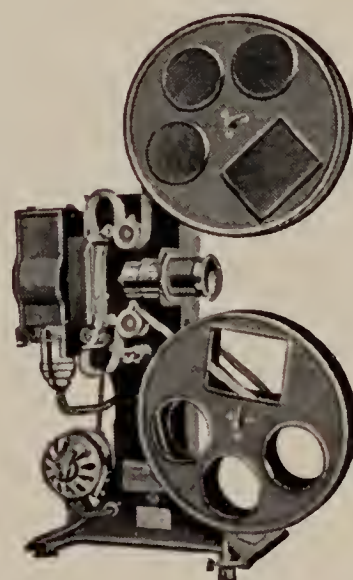


Fig. 193

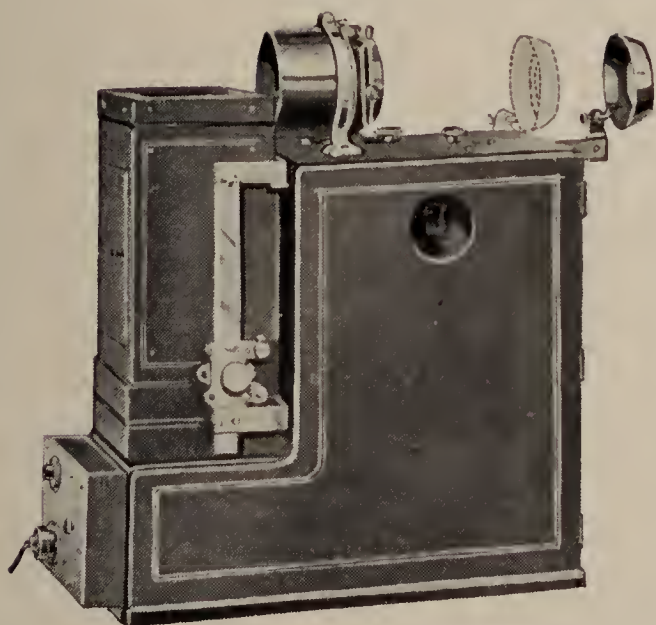


Fig. 194

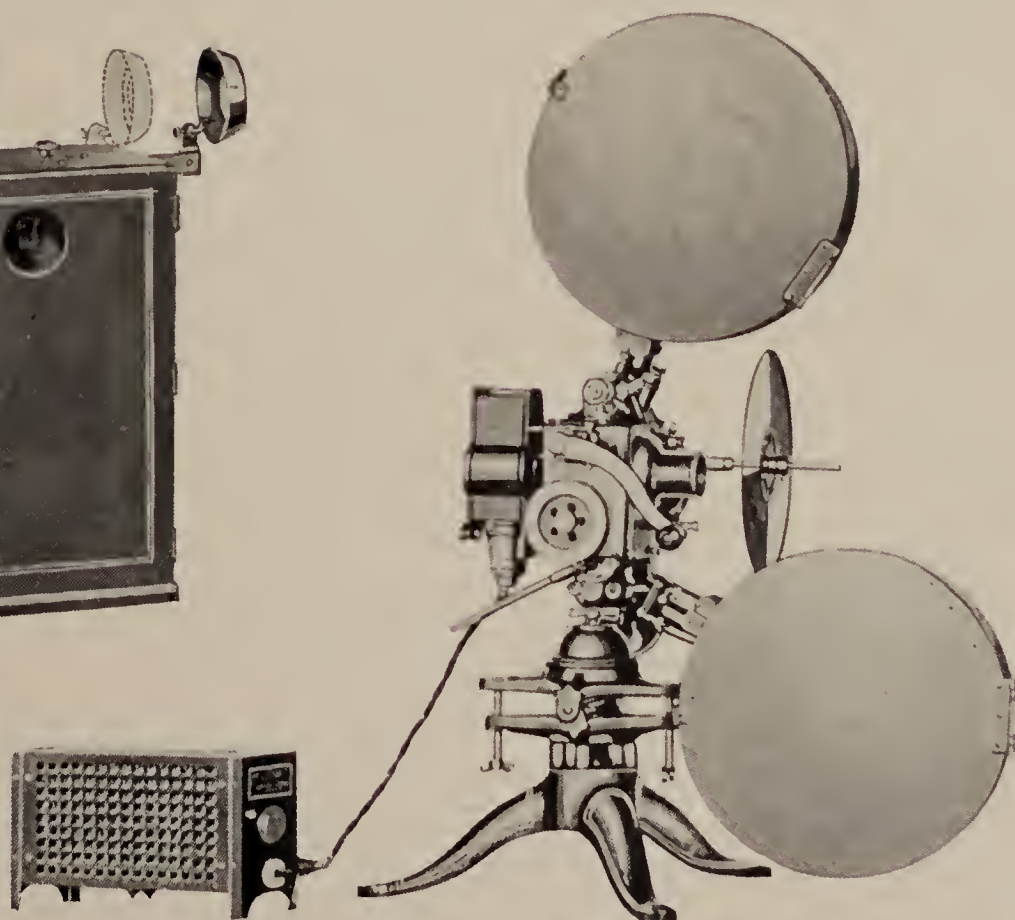


Fig. 195

Four Popular Types of Portable Motion Picture Projectors

Projection Lamps: These machines are usually supplied with one or more spare Mazda lamps. When lamps are to be renewed, care should be taken to see that they are replaced by exactly the same type, current rating and voltage rating.

General Operation: All the machines illustrated above are motor driven as are most of the other portable projectors on the market. Arrangements are provided for some of them to operate with a hand crank in addition. Where necessary, small rheostats are supplied to control the lamp current and the motor, such that the machine can be operated directly from a 110, 115 or 120 volt lighting circuit.

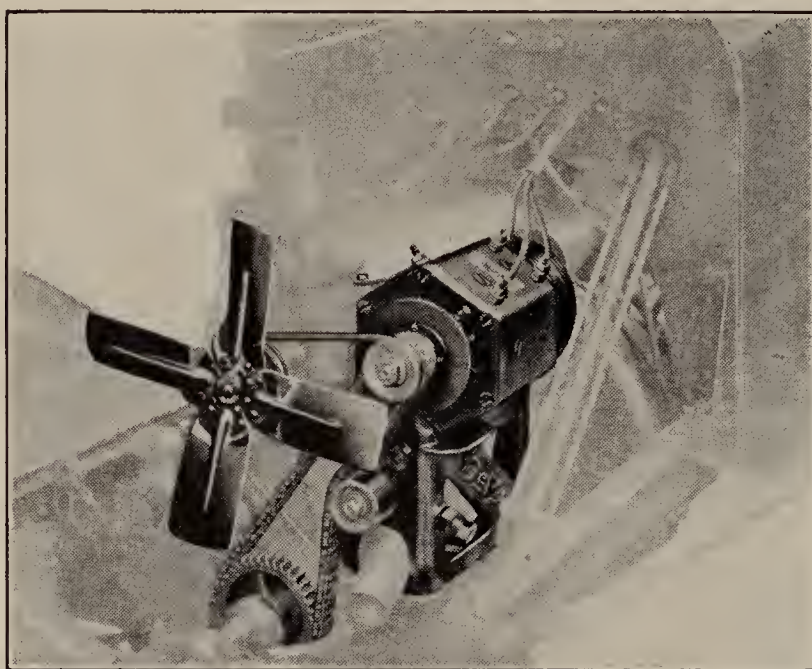


Fig. 196—Automobile Generator Attachment For Operating Portable Projector Where Electric Current is Not Otherwise Available

Automobile Generator: Figure 196 shows a generator attachment for cars, making it possible to use a 28-32 volt projector in places where electric current is not otherwise available.

Stationary Pictures: Several makes of portable projector now on the market are equipped with fire shutters made of special heat absorbing glass. With this arrangement the film can be stopped at any point without injury, and a stationary picture shown on the screen.

FILM

The standard motion picture film used in theatrical work is made with a nitrocellulose base and is highly inflammable. In recent years a material whose base is of cellulose acetate, having the property of being slow burning, has come into widespread use in non-theatrical motion picture work and is often spoken of as safety or non-inflammable film.

Professional Standard Size Film: The use of inflammable film is permitted by the National Board of Fire Underwriters and by practically all local authorities only when the machine is enclosed in a suitable fire-proof booth.

The use of professional standard size non-inflammable film in projectors not enclosed in booths has recently been authorized by the National Board of Fire Underwriters. A few local authorities prohibit such use, due to the ease of substituting inflammable film.

Safety Standard Film: A practice which has gained considerable favor is to make slow burning or non-inflammable film in a slightly smaller size than standard and to build projectors which will take this size film only. This is called "Safety Standard Film." The National Board of Fire Underwriters and practically all local authorities approve the use of the above combination without fireproof booths.

Figures 197 and 198 illustrate the two types of film and show the dimensions which have been adopted as standard by the Society of Motion Picture Engineers.

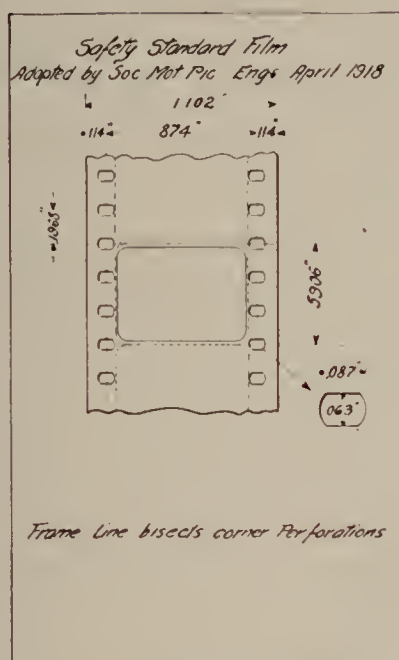


Fig. 197

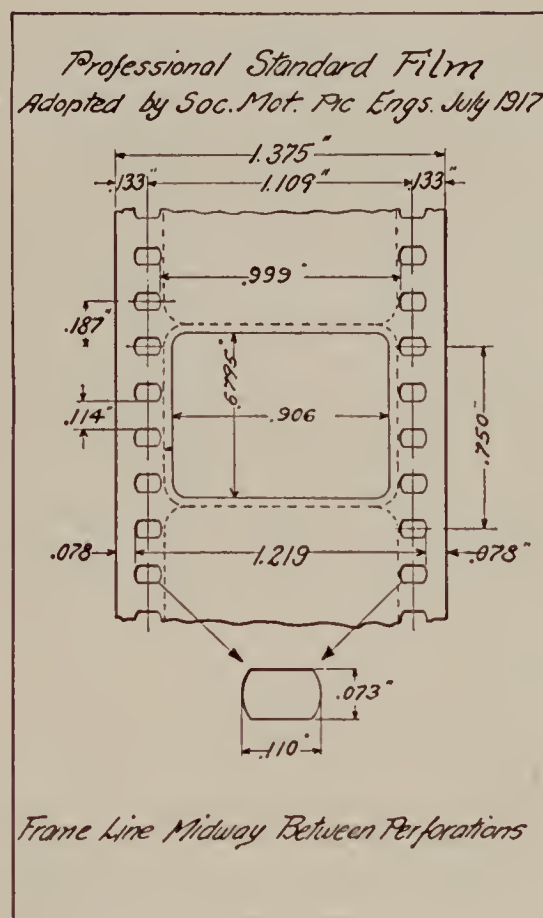


Fig. 198

Film Libraries: There is now in widespread use, apparatus which makes it possible to print positive film of the safety standard size directly from standard size negative film. Film libraries have been equipped in many of the principal cities of the country in which a wide assortment of films are kept on religious, educational, industrial, scientific and dramatic subjects, so that it is now possible to rent a wide variety of films of either the professional standard or safety standard size.

ADVANTAGES OF MOTION PICTURES FOR EDUCATIONAL WORK

Visual Impressions Strongest: The use of motion pictures in educational work represents a most important forward step in this great field. The advantages of motion pictures as a powerful aid in education are many. Most people are "eye-minded," their minds react more quickly to visual impressions and they retain those impressions longer than those secured through any other of the senses. This fact has already been used to a considerable extent by supplementing the reading and oral instruction with diagrams, photographs and stereopticon slides.

Action: The motion pictures, however, show action, an element which produces much clearer impressions, creates interest and is a more effective stimulant to independent thinking than the old still picture.

Speed: The motion picture represents the quickest means of producing and reproducing the desired mental impression. Sometimes a

story is told so quickly that it cannot be grasped, but this objection can be overcome by repeating the picture as often as necessary until the facts are definitely impressed upon the mind.



Fig. 199—Film Library Where Films Can Be Rented or Exchanged

Economy: The motion picture used as an aid in instruction definitely lowers the cost of that instruction in the great majority of cases, if the time of the teacher and the overhead expenses of the educational institution are given the proper consideration.

Common Impression: With pictures the impression produced is the same to all minds. In the case of verbal instructions each mind receives the verbal impression and, where appropriate, creates from it his own visual or mental impression. These may differ considerably according to the intelligence of each individual, but when the visual impression is received direct from the screen it is necessarily the same in every case.

Overcome Time, Space and Size: Motion pictures overcome time, space and size. Extremely slow motion, such as plant growth, can be speeded up as much as necessary for clear and rapid demonstration. In the same way, fast motions may be slowed down sufficiently for careful analysis.

Historical incidents, either recent ones in which the events have actually been filmed, or dramatized historical facts stand ready for unfolding.

The motion pictures can bring into the school great industries in action, mining, agriculture or other activities. Microscopic motion picture photography clearly shows many important transactions in medicine, biology, physics and chemistry.



Fig. 200—Portable Motion Picture Projector in School Room

Animated Drawings: Animated drawings have a tremendous possibility when properly used. As a method of analyzing motion, which cannot be filmed with the ordinary, or ultra-rapid camera, they have no equal. They may be used to analyze subjects which can also be photographed directly. In this case the advantage of the animated drawing lies in the clearness with which certain features of the motion or process can be delineated. Probably the greatest field for the use of animated drawings lies in the depicting of subjects impossible to photograph. Many conceptions, both theoretical and practical, which the teacher may himself understand quite clearly are extremely difficult to impart to the student. Some of these are chemical, electrical and mechanical actions, motions of objects too small to be photographed even with the microscope or in fact to be seen at all. One example is the conception of the motions of electrons, atoms and molecules. The flow of invisible fluids under varying conditions can be demonstrated. Animated drawings can also be used to illustrate great movements covering a tremendous expanse of time, such as typical astronomical and geological movements.

Proofs of Advantages: A number of tests have been made to determine whether or not the use of motion pictures in educational work is an advantage, and, if so, to approximately what extent. Space will be taken here to show the results of only one such test which, however, is typical.*

In the Spring of 1920, tests were conducted on about a dozen pupils of average intelligence in one of the high schools of Madison, Wisconsin. Abstract and concrete subjects were taught to one group by means of films only; to another group by a superior instructor, and to a third group by an average instructor. The film scored an average of 74.5 per cent, the superior teacher an average of 66.9 per cent, and the average teacher, 61.4 per cent. The film outdid the best teacher by 7.6 per cent and the average teacher by 13.1 per cent. It is not to be thought that motion

*Can the Movies Teach? By Rowland Rogers.

Transactions of Society of Motion Picture Engineers, May, 1922.

pictures will replace personal instruction; they are but another powerful tool in the hands of the educator.

Schools Already Using Motion Pictures: A very definite idea of the representation which is being accorded to motion pictures in the schools is given by the following figures:**

Schools in the United States equipped with motion picture projection apparatus about 30,000.

Number of motion picture theatres in the United States about 17,000.

Number of schools in the United States about 280,000.

It is interesting to note that in spite of the tremendous extent to which the motion picture theatres have invaded the entire country, the number of schools in the United States equipped for motion picture projection exceeds the number of motion picture theatres by over 85 per cent.



Teach through the eye

Fig. 201—Portable Motion Picture Projector in School Room

Supply of Educational Films: Due to the fact that practically all of the school organizations of the country are financially limited in making their own films, certain film exchanges have specialized on the supply of films for educational purposes. Some have exchanges or libraries in quite a number of the larger cities of the country wherein a wide selection of films are provided on a rental basis which places them within the financial scope of the majority of the schools. The following outline shows the list of subjects which can be more efficiently taught with the aid of motion pictures. Films on a great many of these subjects are already

available. A considerable number of others are at present in the process of being made.

Subjects Which Can be More Readily Taught by the Aid of Films:

SCIENCE

Botany
Zoology
Chemistry
Physics
Astronomy

HISTORY

Events actually photographed
Modern
Dramatized
Prehistoric
Ancient
Mediaeval
Modern

RELIGION

Biblical History

MATHEMATICS

GEOGRAPHY

PHYSICAL GEOGRAPHY

GEOLOGY

FINE ARTS

Drawing
Painting
Sculpture
Architecture

**Pedagogical Motion Pictures. By Carl Anderson.
Transactions of Society of Motion Picture Engineers, October, 1922.

PHILOSOPHY

LANGUAGE

LITERATURE

SOCIOLOGY

CIVICS

USEFUL ARTS

Medicine

Physiology

Hygiene and Health

Domestic Science

Mechanical Arts

Electrical Arts

Chemical Arts

INDUSTRIES

Lumber and Forestry

Fishing

Mining

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Manufacturing

Shipping

STEREOPTICON PROJECTION HISTORICAL

The art of projecting pictures on a screen has been known and practiced to a limited extent as far back as the year 1700. The early projectors which were used for this purpose were naturally very clumsy and unsatisfactory. Up until a few years ago the sources of illumination which were used in stereopticons were the carbon arc, lime light and acetylene gas flame.

With the development of the Mazda lamp for lantern projection a new light source with the desirable features of cleanliness, intense brilliancy and great convenience was made possible. At first the Mazda lamp was not universally used, due to the fact that electric current was not everywhere available. This objection has gradually become less and less important until the present time when almost every town of any size has its electric current supply. There are still a few cases where acetylene is used, but these are limited to the situations where it is necessary to show the pictures in the most remote places where electric current is not available. Even in the most out of the way places, however, isolated home lighting plants are frequently available and are quite satisfactory as a power supply for the proper Mazda stereopticon lamp.

USES FOR STEREOPTICONS

Stereopticon projectors of several different types have a wide field of use similar to that described in the chapter on portable motion picture projectors. The field of usefulness of the stereopticon, however, is even wider, due to the fact that it is a little easier to carry and requires less skill in operation. In addition, lantern slides, sufficient for an hour's talk, are considerably less expensive than a film of sufficient size for the same purpose. The most important fields for these stereopticons are in:

Class Rooms

Lecture Halls

Churches

Home

Welfare Work

Business

Selling

Demonstration

The stereopticon is familiar to everybody and the advantages of its uses in most of the above fields are self evident. Automatic stereopticons to project a succession of lantern slides in a predetermined order are rapidly increasing in popularity as a means of advertising in show windows and at conventions.

For lectures and for school educational work there are many excellent sets of lantern slides on important subjects which can be rented from commercial organizations.

In addition to the use of stereopticon lamps in lantern slide projectors, they are employed in the medical profession, in theatrical spot lighting, and for a variety of other purposes.

LAMPS

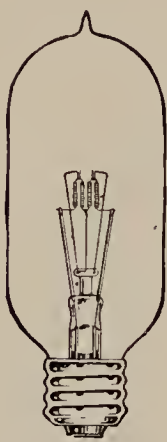


Fig. 202
30 Volts
300 Watts



Fig. 203
110-115-120 Volts
250 Watts



Fig. 204
110-115-120 Volts
400 Watts

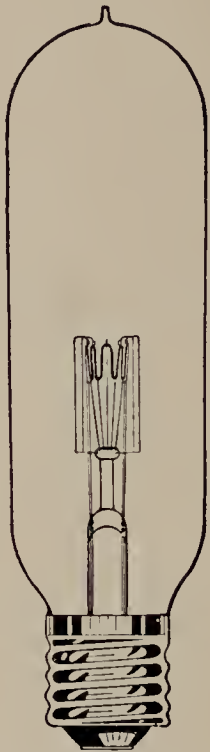


Fig. 205
110-115-120 Volts
1000 Watts

MAZDA C LAMPS—PROJECTION—TUBULAR BULBS
28-32 VOLTS

AMPS.	WATTS	HOURS LIFE	BULB	DIAM. OF BULB	SCREW BASE	MAX. OVERALL LENGTH	LIGHT—CENTER POSITION*	POSITION OF BURNING	PACKAGE QUANTITY	LIST PRICE
..	300	100	T-16	2"	Medium	5 5/8"	3"	Tip-up	12	\$2.75
20	600	100	T-20	2 1/2"	Mogul	9 1/2"	4 3/4"	Tip-up	6	6.00
30	900	100	T-20	2 1/2"	Mogul	9 1/2"	4 3/4"	Tip-up	6	6.75

MAZDA C LAMPS—PROJECTION—TUBULAR BULBS
110, 115 AND 120 VOLTS

..	250	100	T-14	1 3/4"	Medium	5 5/8"	3"	Tip-up	24	\$1.75
..	400	100	T-20	2 1/2"	Medium	5 5/8"	3"	Tip-up	6	3.00
..	1000	100	T-20	2 1/2"	Mogul	9 1/2"	4 3/4"	Tip-up	6	7.00

MAZDA C LAMPS—PROJECTION—ROUND BULBS
110, 115 AND 120 VOLTS

..	100	100	G-25	3 1/8"	Medium	5 1/8"	3"	Tip-up	60	\$1.10
..	250	100	G-30	3 3/4"	Medium	5 9/16"	3"	Tip-up	24	1.85
.	400	100	G-30	3 3/4"	Medium	5 9/16"	3"	Tip-up	24	3.25

*The distance in inches from base contact of lamp to center of filament.

Bulb and Filament Shapes: Mazda lamps for stereopticon service are made in both tubular and round bulbs. The tubular bulb lamps are the same as shown in the chapter on portable motion picture projectors. The round bulb lamps are similar except for the shape of the bulb and for the fact that the filament coils are located in a circle, or as it is more commonly known, in the "barrel construction." The filament sections in the tubular bulb lamps are arranged in a flat plane or in the monoplane construction.

Testing and Life: As explained in the description of the motion picture lamp, these lamps are the result of a great amount of design work and thorough testing, both in the engineering laboratories and in actual service work. They represent the most highly developed line of Mazda lamps to meet the most rigid service requirements of ruggedness and brilliancy. Stereopticon lamps are made as is the case with lamps for motion picture service to operate for one hundred hours life. The adoption of a reasonably short figure of one hundred hours life makes it possible to produce a lamp which will give a much more intense light than would be the case if the lamp were designed for one thousand hours life, as is done for most Mazda lamps in general lighting service.

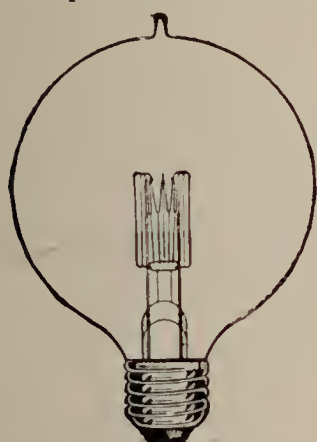


Fig. 206
110-115-120 Volts
100-250-400 Watts

Voltage: The 110, 115 and 120 volt lamps may be connected directly across the supply lines of those voltages without the use of rheostats or meters. If the stereopticon is to be used in a certain place continually, a lamp should be chosen with the voltage nearest that of

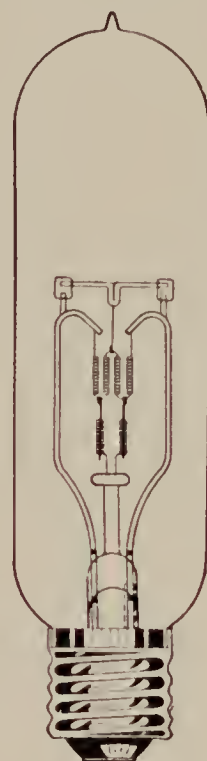


Fig. 207
30 Volts
900 Watts

the supply line. If the lantern is to be carried from place to place, probably the safest thing to do would be to use a 115 volt lamp; or, still better, carry several lamps of different voltages so that the proper one can be used at each place. A 120 volt lamp burning at 110 volts will produce only a small proportion of the normal amount of light. A 110 volt lamp burning at 120 volts would give an intense light but its life will be so shortened as to represent poor economy.

28-32 volt lamps are built primarily for use where that supply voltage only is available, as in the familiar isolated electric plants using a gas engine and storage battery.

Applications for Different Sizes: A lamp with a power consumption of under 660 watts is allowed by the National Board of Fire Underwriters to be burned on any ordinary light circuit, providing other lamps are not connected with the same circuit to bring the total above 660 watts. A lamp with a power consumption greater than 660 watts must be connected by a special line direct to the distributing panel.

For the projection of lantern slides the 250 watt lamp is suitable for the average class room, home or small church room pictures. The 400 watt lamp should be used for moderate size lecture halls and the 1000 watt lamp for large halls and theatres. For the projection of opaque objects, in the special lanterns designed for that purpose, as large a lamp as possible should be used.

GENERAL

Principles of Stereopticon Projection: In general the principles of satisfactory projection are the same as for that of motion pictures. These principles are discussed in detail on pp. 5-19, inc. There are several essential points of difference between the two, however, as outlined below.

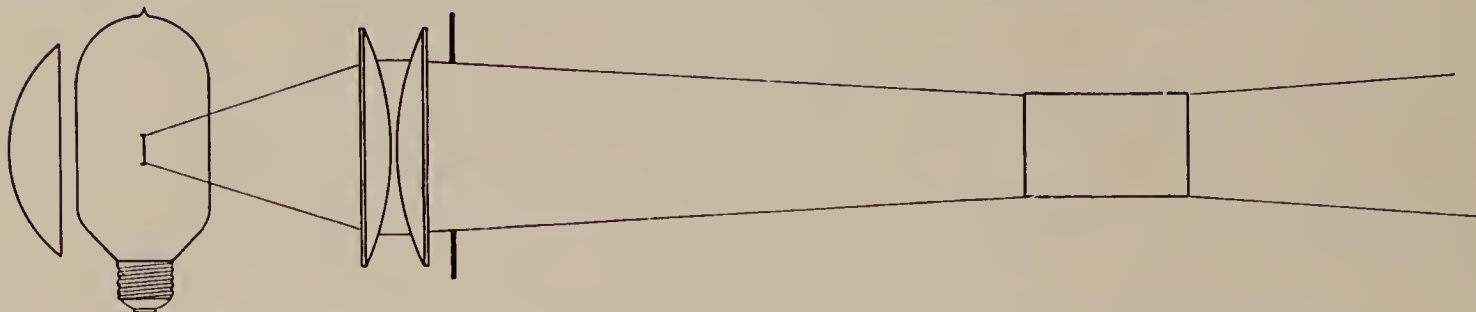


Fig. 208—Complete Optical System for Stereopticon Projection with Mazda Lamps

Large Aperture: Due to the fact that the aperture or opening in the lantern slide holder is much larger than the film aperture in the motion picture machine the slide can be placed quite close to the condenser. Plano-convex condensers are at present used in practically all cases for slide projection. With such lenses the beam of light is uniform on passing through the slide and consequently the screen illumination is uniform even in cases where the light source is such that it would not be satisfactory for motion picture projection. In other words, the requirements for the lamps in stereopticon work are not so exacting. Another advantage in stereopticon lamp requirements is that the beam does not have to be brought down to a very narrow width as in the case where the beam must pass through the film aperture in motion picture projection.

Condenser Lens: The condenser lenses suitable in most cases for stereopticon projection are $4\frac{1}{2}$ inches in diameter and of $6\frac{1}{2}$ and $7\frac{1}{2}$ inch focus. These are the same type as described under the title "Standard Motion Picture Projection, Plano-Convex."

Objective Lens: The objective lens in a lantern is of much longer focus for a given picture size and projection distance than is the case with motion picture projection. This is due to the fact that the lantern slide is much larger than the individual picture on the motion picture film.



Fig. 209—400 Watt Mazda Lamp with Holder and Mirror

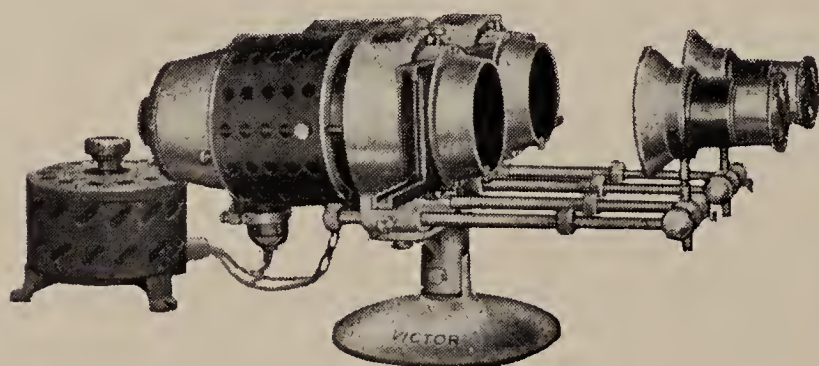


Fig. 210—Double Dissolving Stereopticon



Fig. 211—Combination Projector for Display of Slides or Opaque objects

The following table shows the objective lenses necessary to give certain picture sizes at different distances from the screen.

TABLE OF PICTURE SIZES, PROJECTION DISTANCES AND FOCAL LENGTHS OF STEREOPTICON SLIDES
Distance from Slide to Screen, Feet

LENS FOCUS IN INCHES	20	25	30	35	40	45	50	60	70	80	90	100
10	*5.3	6.6	8.0	9.4	10.8	12.2	13.5	16.3	19.0	21.8	...	...
	†5.8	7.3	8.8	10.3	11.8	13.3	14.8	17.8	20.8	23.7	...	...
12	...	5.5	6.6	7.8	8.9	10.1	11.2	13.5	15.8	18.1	20.0	....
	...	6.0	7.3	8.5	9.8	11.0	12.3	14.8	17.3	19.8	22.2	....
14	..	...	5.6	6.6	7.6	8.6	9.6	11.6	13.5	13.5	17.5	19.4
	..	...	6.2	7.3	8.3	9.4	10.3	12.6	14.8	16.9	19.0	21.2
15	..	..	..	6.2	7.1	8.0	8.9	10.8	12.6	14.4	16.3	18.1
	..	...	...	6.7	7.7	8.7	9.7	11.7	13.7	15.7	17.7	19.7
16	..	...	...	5.8	6.6	7.5	8.4	10.1	11.8	13.5	15.2	17.0
	..	...	...	6.3	7.3	8.2	9.1	11.0	12.9	14.8	16.6	18.5
17	..	..	...	3.4	6.2	7.0	7.8	9.5	11.1	12.7	14.3	15.9
	..	..	..	5.9	6.8	7.7	8.6	10.3	12.1	13.9	15.7	17.5

* Picture height in feet. † Picture width in feet.

It should be noted that a projection lens of a certain focal length will give different size pictures at different distances from the screen, so that a lens which is chosen to meet average conditions can be used satisfactorily, except in extreme cases, by simply moving the lantern nearer to or farther away from the screen.

Setting the Optical System: Frequently the maximum light on the screen is not obtained from a projector due to incorrect adjustment. The adjustment of the lamp should be checked before each lecture if the machine is carried about, or every few days if the machine is permanently set up, as a small error in adjustment will cause a very considerable loss of light on the screen.

If the setting must be made in a hurry, throw the mirror entirely out of line or hold a piece of cardboard between it and the lamp. Focus the edges of the slide holder on the screen and move the lamp up and down, sideways, and back and forth until the screen becomes brightest and most uniform; then bring the mirror into play and adjust it at the point where the screen looks best.



Fig. 212—Automatic Stereopticon



Fig. 213—Portable Stereopticon

The above method is recommended only in the case where the adjustment has to be made quickly. It is not particularly accurate, due to the fact that it is hard for the eye to judge closely when the maximum brightness of the screen is obtained. For a better method of adjusting proceed as follows:

- a. Remove the objective lens.
- b. Throw the mirror out of line or hold a card between it and the lamp.
- c. Move the lamp back and forth until the images of the filament appear sharply focused on the screen.
- d. Move the lamp up and down and sideways until the center of the entire bank of filament sections appears in the center of the field of light on the screen.

e. Bring the mirror approximately into adjustment. A secondary set of filament images will be seen on the screen similar to the ones just described. Move the mirror until these are sharply in focus and sandwich them in between the first images in much the same manner as shown in the case of the motion picture lamp, Figure 128-B, page 15.

f. Replace the objective lens in the outfit and move the lamp and mirror together backward and forward until the most satisfactory appearance of the screen is obtained.

Clean the lamp, lenses and mirror every day with a soft, dry rag, or if the equipment is not used every day clean it immediately before using each time. A small amount of dust and dirt will materially cut down the brightness of the picture.

**Types of Stereopticons:* Figs. 43, 2, 62, 54 and 11 show several types of stereopticon outfits which have been built to meet a wide variety of requirements.

Screens: In cases where it is necessary to have the screen out of the way when not actually in use, the ordinary roller type mounted on a suitable spring roller is recommended. For portable work there are several types of

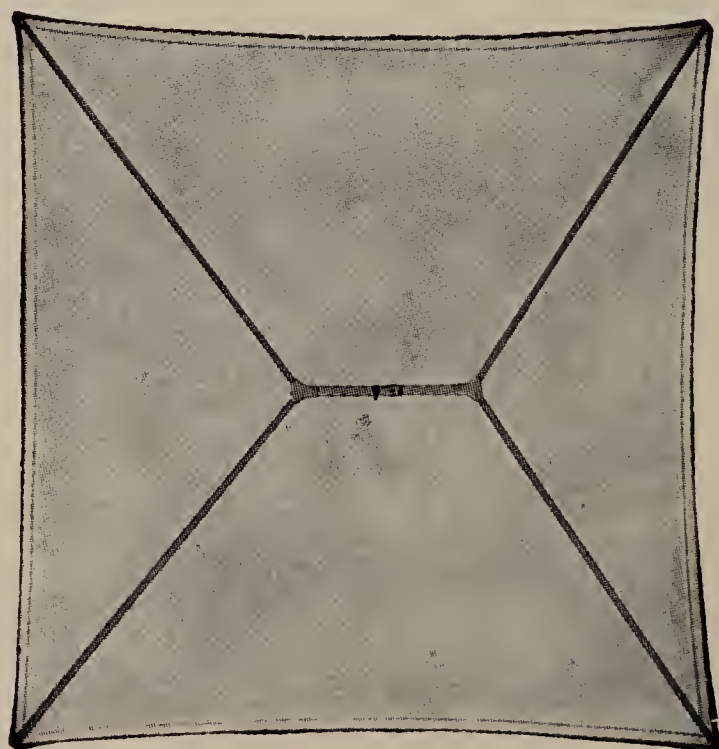


Fig. 214—Convenient Stretcher for Small Stereopticon Screen

screen which can be folded up.

* See Figures 210 to 213 inclusive, and Figure 215

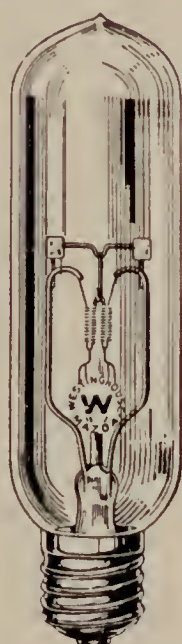


Fig. 215—Stereopticon and Screen Arrangement capable of being operated by the Lecturer

More complete information on these will be found in the chapter on screens for portable motion picture projectors.

As explained in the discussion on screens for standard size motion picture installations, a diffusing white screen should be used in wide rooms and a metallic or beaded type in long narrow rooms.

Opaque Projection: Where it is necessary to project opaque objects, the intensity of light on the screen is necessarily low. For such work the room should be entirely darkened. Since the metallic or beaded screen will give a brighter picture directly in front of the screen, it is recommended that if possible, even where the lecture room is wide, a metallic or beaded screen be used and the audience grouped as nearly as practicable immediately in front of the screen.



THE Illumination Bureau of the Westinghouse Lamp Company, having accumulated a large amount of engineering information and experience on this subject, will be glad at any time to furnish engineering advice regarding motion picture and stereopticon projection with Mazda lamps.

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